U.S. Department of Homeland Security
500 C Street, SW
Washington, DC 20472

FEMA

April 27, 2005

Steven Aftergood
Federation of American Scientists
1717 K St, NW
Washington, DC 20036

RE: Freedom of Information Act Request
FOIA Case No.: 04-098

Dear Mr. Aftergood:

This letter is in response to Allen Thomson's February 12, 2004 Freedom of Information Act (FOIA) request. In that request, he asked for a copy of "Nuclear Attack Planning Base 1990 Final Project Report," dated April 1987, an out-of-print FEMA publication.

In responding to a FOIA request, the U.S. Department of Homeland Security (DHS)/Federal Emergency Management Agency's (FEMA's) search will include responsive records in its control on the date the search began. FEMA's search began on February 19, 2004.

Your request is granted in full at no cost to you. Please include the following caveat in any further posting of this publication. "This publication was provided by the Federal Emergency Management Agency, Department of Homeland Security, for its academic and historical value only." Enclosed please find the FEMA library reference copy on loan to you for duplication. Kindly return the publication to me when you complete the task and include the url information for your website.

For your information, this FOIA request, including Mr. Thomson's identity and the information made available, is releasable to the public under subsequent FOIA requests. In responding to these requests, FEMA does not release personal privacy information, such as home address, telephone number, or social security number, all of which are protected from disclosure under FOIA Exemption 6.

Thank you for your interest in FEMA's programs and policies.

Sincerely,

Elaine I. Chan
General Attorney
Office of General Counsel
500 C St, SW
Washington, DC 20472

Enclosure
Cc: Allen Thomson

K. Petersen

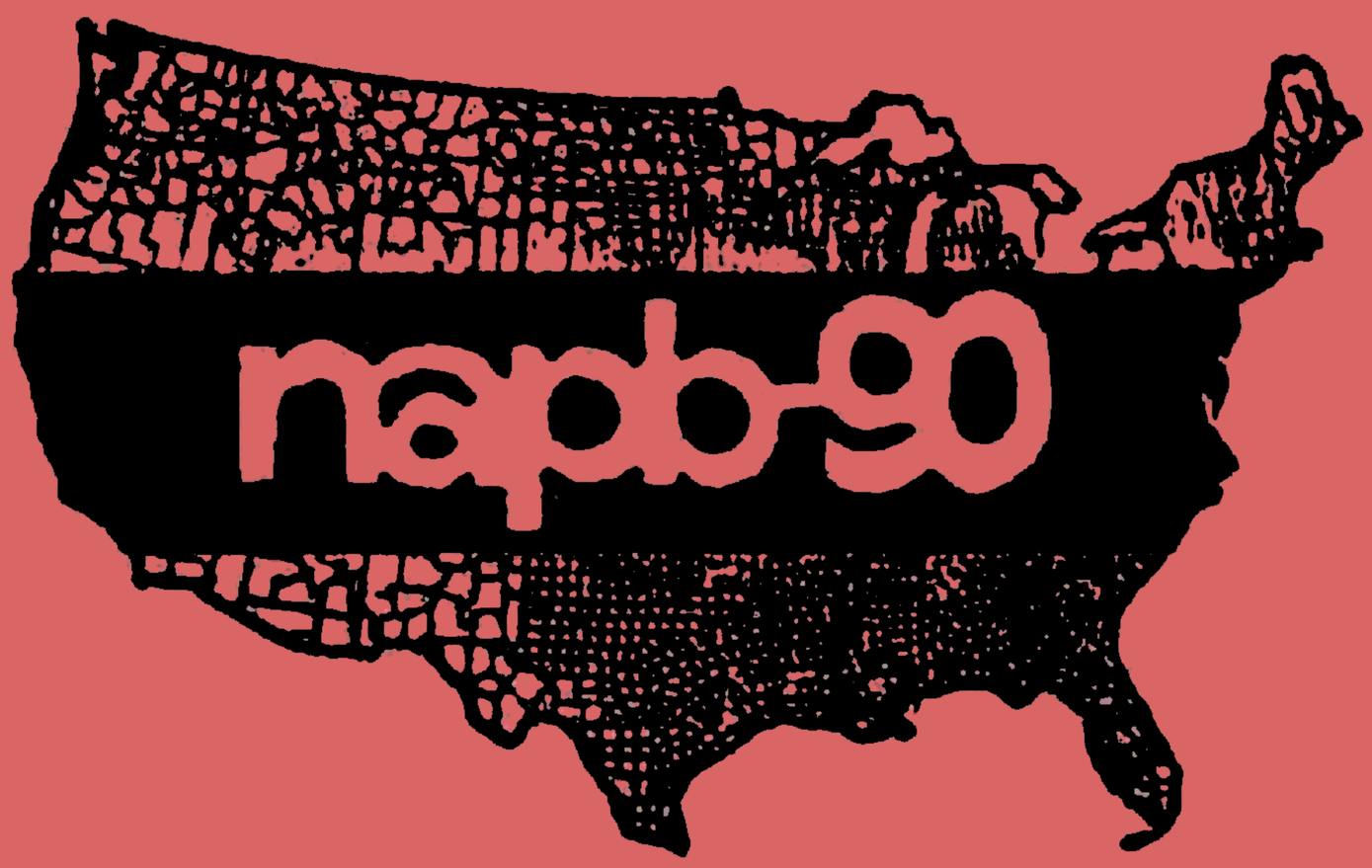
FEDERAL EMERGENCY MANAGEMENT AGENCY

April 1987

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Nuclear Attack Planning Base-1990 Final Project Report

Part 1 Project Overview
Part 2 Project Development
Part 3 Risk Definitions



Federal Emergency Management Agency

NUCLEAR ATTACK PLANNING BASE - 1990 (NAPB-90)

F I N A L P R O J E C T R E P O R T

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ANNEX A: DIRECT EFFECTS/FIRE RISK - STATISTICS & MAPS

ANNEX B: FALLOUT RISK - STATISTICS & MAPS

A C K N O W L E D G M E N T S

This report represents many hours of work by professionals in and out of government whose experience and knowledge covered a wide spectrum of academic and governmental disciplines in nuclear weapons effects and civil preparedness planning. Grateful acknowledgment is made for the contributions of participants of the informal Nuclear Attack Planning Base - 1990 Working Group who met voluntarily to discuss, debate, and decide policy and planning considerations. In this regard, special acknowledgment should be made of the high degree of professionalism displayed by Donald Moore and his staff in the Systems Development Division, OP-IR-SD, in the generation of computer data for Working Group discussions and for this report.

Lastly, I must acknowledge the welcome advice, encouragement, and generous support accorded this project by Joseph A. Moreland, Assistant Associate Director, SL-EM.

The final shape and thrust of NAPB-90 is the result of the unstinting dedication, enthusiasm, and effort of all project participants.

Ronald F. Treichel
Executive Officer, SL-EM
NAPB-90 Project Coordinator

NUCLEAR ATTACK PLANNING BASE - 1990

E X E C U T I V E S U M M A R Y

PROJECT OVERVIEW

The NAPB-90 project was an in-house project of the Federal Emergency Management Agency (FEMA) carried out over a year and a half from early 1985 to 1986. The project was coordinated by the Office of Emergency Management Programs, State and Local Programs and Support Directorate, and involved professionals and experts from FEMA directorates and offices, other Federal departments and agencies, and the private sector.

The NAPB-90 is an estimate of the potential physical effects of a nuclear attack on the population of the United States in terms of the degree of the potential risk.

Three types of potential nuclear attack effects risks and the areas and populations affected by each are defined:

- The direct effects risk from blast overpressure generated by the explosion of a nuclear weapon;
- The potential thermal and secondary blast-ignited fire risk created by the combined effects of blast overpressure damage and the thermal pulse or fireball of a weapon; and
- The fallout risk from radiation generated by surface-burst weapons.

The development of the planning base followed detailed studies of all aspects of nuclear attack planning, but despite such efforts specific confidence limits cannot be assigned to either implicit or explicit assumptions used regarding targeting, weapon yields and designs, heights of burst, and delivery system accuracy and reliability. In short, NAPB-90 does not (and cannot) claim total realism.

PROJECT DEVELOPMENT

An initial study of Soviet military objectives, war-fighting scenarios, targeting strategies, and force applications provided the basis for many of the developmental procedures and policies of NAPB-90. In the development of the target base, for example, close attention was paid to frequent Soviet references to damage limitation strategies, particularly those involving non-target resources of the enemy. This element significantly influenced procedures used in making final possible enemy target selections.

NAPB-90 is a scenario-independent study since Soviet targeting priorities (as well as their strategic objectives) remain essentially the same regardless of the *a priori* scenario under which their weapons would be employed.

All of the NAPB-90 targets were developed and carefully edited to conform to both Soviet-declared strategic objectives and force deployment principles. Initial and subsequent iterations of the target base were compared against listings of projected 1990 Soviet strategic nuclear forces in order to assure logical weapon employments. All aim points finally selected were attacked using Soviet strategic targeting procedures to assure realistic weapon employment. In this respect, the following targeting factors were used in weapon selection and employment:

- The height of weapon detonation representing the height which would be selected by the Soviet strategic planner for weapon detonation;
- The Soviet views regarding expected surface characteristics of selected U.S. targets which would influence the extent of blast overpressures generated;
- The vulnerability of U.S. targets to blast overpressures assumed by the Soviet planner; and
- The probability of damage or destruction of the target influenced by the accuracy of the Soviet weapon and its probability of arrival on target.

In short, all Soviet weapons were employed as if by a Soviet strategic planner. Thus, NAPB-90 is not a "mirror-image" attack in which weapons and targets are chosen from a U.S. point of view.

RISK DEFINITIONS

Direct Effects - NAPB-90 defined the potential risk from nuclear weapon blast overpressures as the total area affected by 0.5 pound per square inch (psi) or more. This represents 727,112 square miles of the U.S. with an estimated resident population of 175.1 millions. Since NAPB-90 does not target population *per se*, the persons affected by blast overpressures reside in areas which are peripheral to or collocated with potential military and industrial targets.

Four degrees of the potential risk from blast overpressure were delineated, based on the severity of short-term threat from the blast wave itself and its potential to kill or injure; the potential long-term severity to survivors within the blast area; and the kind, degree and practicality of in-place and/or crisis-general measures necessary for protection.

- Very High Direct Effects Risk Areas were defined as areas surrounding target aim points which have the potential to experience blast overpressures equal to or greater than 10.0 psi from a nuclear detonation(s). Approximately 47.2 million persons (19 percent of the population) reside in Very High Direct Effects Risk Areas which cover approximately 46,352 square miles.
- High Direct Effects Risk Areas were defined as areas around a target aim point which have the potential to experience blast overpressures from a nuclear weapon detonation of equal to or greater than 5.0 psi

but less than 10.0 psi. Approximately 32.2 million persons (13 percent of the population) reside in High Direct Effects Risk Areas which cover approximately 49,896 square miles.

- Medium Direct Effects Risk Areas were defined as areas around target aim point which have the potential to experience blast overpressures from a nuclear weapon detonation(s) of equal to or greater than 2.0 psi but less than 5.0 psi. Approximately 50.3 million persons (21 percent of the population) reside in Medium Direct Effects Risk Areas which cover approximately 151,535 square miles.

- Low Direct Effects Risk Areas were defined as areas around target aim point which have the potential to experience blast overpressures from a nuclear weapon detonation(s) of equal to or greater than 0.5 psi but less than 2.0 psi. Approximately 45.4 million persons (19 percent of the population) reside in Low Direct Effects Risk Areas which cover approximately 479,329 square miles.

In sum, approximately 72 percent of the U.S. population is potentially affected by blast overpressures 0.5 psi or more, with 67 million persons living outside the total area defined as at direct effects risk.

Fallout Risk - The potential risk from fallout radiation generated by ground-burst weapons is vast and far-reaching. NAPB-90 defined the entire continental U.S. as under this potential risk, basing its risk assessment on the potential effect of fallout radiation on the resident population over a period of one week following the deposition of fallout and the efficacy of shelter protection to mitigate such exposure. Longer-term effects (additional cancer deaths and potential death in future progeny) were also considered.

To determine risk levels for U.S. counties, NAPB-90 employed the combined results of 12 "most-likely" wind patterns--one such pattern for each month of the year--and used the highest resulting radiation effect in each county as its potential risk level.

Four levels of potential fallout risk were defined:

- Very High Fallout Risk Counties were defined as those which have the potential to receive a one-week unprotected radiation dose of equal to or greater than 15,000 roentgens (R). The counties which were defined at this risk level have resident populations totaling 9.6 millions (4 percent of the U.S.) and cover approximately 421,669 square miles.

- High Fallout Risk Counties were defined as those which have the potential to receive a one-week unprotected radiation dose of equal to or greater than 6,000 roentgens but less than 15,000 roentgens. The counties which were defined at this risk level have resident populations totaling 49.2 millions (20 percent of the U.S.) and cover approximately 624,407 square miles.

- Medium Fallout Risk Counties were defined as those which have the potential to receive a one-week unprotected radiation dose of equal to or greater than 3,000 roentgens but less than 6,000 roentgens. The counties which were defined at this risk level have resident populations totaling 62.6 millions (26 percent of the U.S.) and cover approximately 618,811 square miles.

- Low Fallout Risk Counties were defined as those which have the potential to receive a one-week unprotected radiation dose of less than 3,000 roentgens. The counties which were defined at this risk level have resident populations totaling 120.8 millions (50 percent of the U.S.) and cover approximately 1,886,339 square miles.

NAPB-90 does not recommend the types and degree of shelter protection best suited to the individual fallout risk areas, but rather delineates the short and long-term consequences of selecting shelter of varying quality, stressing that the ultimate aim is "zero exposure."

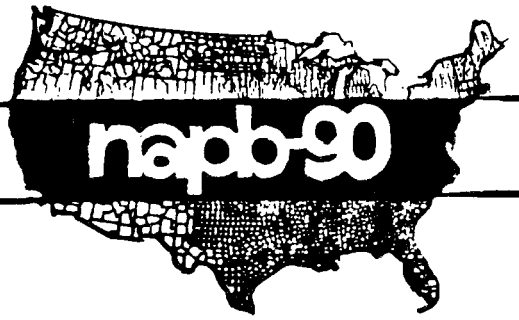
Fire Risk - The risk of potential thermal and secondary blast-ignited fires created is directly related to the risk from blast overpressures. Hence, NAPB-90 defined the fire risk as coexistent with that risk, delineating three degrees of risk:

- Very High Fire Risk Areas exist where blast overpressures equal or exceed 5.0 psi, that is, the areas defined as at very high and high direct effects risk. Survivors in these areas would almost certainly perish should any fires occur since search and rescue, evacuation, and fire fighting are considered almost impossible to accomplish.

- High Fire Risk Areas exist where blast overpressures are greater than 2.0 psi but less than 5.0 psi, that is, the areas defined as at medium direct effects risk. The characteristics of damage created by this range of overpressure (generally standing but heavily damaged buildings) are conducive to the generation and spread of mass fires. As in the Very High Fire Threat Area, emergency operations to assist survivors as well as to control or extinguish fires are almost impossible to accomplish.

- Medium Fire Risk Areas comprise the remainder of the area of potential blast overpressure, that is, the area experiencing equal to 0.5 psi but less than 2.0 psi. While blast-induced fires are less likely at this range of overpressure, thermal ignitions remain a distinct hazard, particularly when such ignitions occur indoors.

PART 1. PROJECT OVERVIEW



A. General Overview - The NAPB-90 project was an in-house effort of the Federal Emergency Management Agency (FEMA) carried out over a year and a half from early 1985 to 1986. The project was developed and coordinated by the Office of Emergency Management Programs, of the State and Local Programs and Support Directorate, and involved professionals and experts from FEMA directorates and offices, other Federal departments and agencies, and the private sector.

1. Purpose - The current nuclear attack planning base outlined in FEMA publication TR-82, "High Risk Areas for Civil Preparedness Nuclear Planning Purposes," which represented a 1975 assessment of the potential effects of nuclear attack through 1985. Since its publication, major changes have occurred which make this planning base obsolete. These changes are discussed below. NAPB-90 replaces TR-82 and provides a nuclear attack planning base for assessing and planning for preparedness measures for today and through 1990. The unprecedented destructiveness of strategic nuclear weapons and the possibility (however remote) of their use in war deserve the serious concern of government at all levels.

2. Scope - NAPB-90 is an estimate of the potential physical effects of a nuclear war on the population and land area of the United States in terms of the degree of the potential risk from these effects. In developing such risk assessments, the project incorporated publicly available data on Soviet nuclear warfighting objectives; the strategic nuclear arsenals available to carry out such an attack; and Soviet targeting objectives and force deployment procedures.

Three types of potential nuclear attack effects risks and the areas and populations affected by each are defined by NAPB-90:

- The potential direct effects risk from blast overpressure generated by the explosion of a nuclear weapon (measured in pounds per square inch [psi] over normal air pressure);
- The potential risk from thermal and secondary blast-ignited fires created by the combined effects of blast overpressure damage and the thermal pulse (or fireball) of a weapon; and
- The risk from potential fallout radiation generated by surface-burst nuclear weapons.

All attack effects were determined using the FEMA READY nuclear effects assessment system and the FEMA Population Grid File (PGF). All computer work was under the supervision of the Computer Systems Division, Office of Information Resources Management, Emergency Operations Directorate. In most instances, NAPB-90 potential risk areas were defined to match complementary preparedness measures necessary to mitigate weapon effects, as well as long-term steps to maintain life support in the threat area. Risk area definitions are found in Part 3, "Risk Definitions." Specifically identified areas and populations affected are outlined in Part 3.A. "Direct Effects Risk;" Part 3.B., "Fallout Risk;" and Part 3.C., "Thermal and Secondary Blast Fire Risk." Annexes A and B contain statistics and maps concerning these threats.

3. Limitations - NAPB-90 was developed after detailed studies of all aspects of nuclear attack planning. Despite such efforts, there is no way to assign specific confidence limits to either the implicit or the explicit assumptions used regarding targeting, weapon yields and designs, heights of burst, accuracy, and delivery system reliability. The only confidence which can be claimed by NAPB-90 is that it represents a credible estimate of the potential risk from a large-scale nuclear attack on the U.S., having been constructed on logical, studied assumptions and available emperical data. Hence:

- NAPB-90 cannot be used to predict how a nuclear war would be fought against the U.S. but merely identifies areas and populations which are at potential risk from nuclear weapon effects;

- NAPB-90 does not speculate on the strategic priority which might be given specific targets by Soviet planners (although an overriding assumption would be that destruction of U.S. strategic counterforce facilities would be a very high priority). The planning base, therefore, represents no specific war-fighting scenario;

- NAPB-90 acknowledges only the classes of targets used in the development of the planning base but does not identify individual targets by their strategic value (see Part 2.b., "Target Selection");

- NAPB-90 makes no assumptions regarding potential population casualties acknowledging only the numbers of residents, day-to-day populations within defined risk areas; and

- NAPB-90 does not purport to be totally predictive (100 percent correct) in its presentation of potential risks from direct effects, fire, and fallout. This is particularly true for fallout risk area definitions where the total risk following an attack would be driven by weather conditions at that time.

In short, no nuclear attack planning base or any study involving nuclear war can claim total accuracy since there is no way of knowing Soviet war plans.

B. TR-82 vs. NAPB-90 - As stated earlier, the purpose of the NAPB-90 project was to update and replace the nuclear attack planning base represented in FEMA publication TR-82, 1979. While a comparison of the differences between TR-82 and NAPB-90 is difficult since each base approached the problem of defining risk uniquely, the following is presented as illustrative of the differences in the approaches to define potential risks.

1. General Comparisons - While NAPB-90 projections on populations and areas subject to nuclear attack effects are configured differently than in TR-82, a general comparison of compatible data can illustrate the significant differences between the two bases.

To determine risk areas, NAPB-90 employed the FEMA Population Grid File (PGF) which divides the U.S. land area into squares of 2 minutes latitude and longitude. Each square is approximately 2 1/4 miles per side, or roughly 5 square miles in area. The center of each square is used as a reference point for all resources within the square. A total of approximately 115,000 such points constitute the entire file.

Overpressure computations were done at 2-mile intervals from the assumed ground zero (detonation point or AGZ) of a weapon for total distances of 25 miles in all compass directions. These generated 2-mile intervals from the AGZ coincide with the grids of the PGF.

Fallout computations were done at 10-mile intervals, effectively at each corner of a 10-mile grid using approximately 55,000 such points.

The basic data of each grid point are the resident population of the square and standard Bureau of the Census geographic codes (State, county, minor civil division, and Standard Metropolitan Area, as applicable). In addition, applicable resources data were identified by geographic location (i.e., latitude and longitude coordinates), summarized, and "attached" to the appropriate PGF point. Finally, overpressure and fallout effects were overlayed on the PGF for effects analysis.

The developers of TR-82 used the bounding limit of 2.0 psi overpressure as a definition of risk from nuclear detonations. The reason for this choice is sound, but NAPB-90 expanded and refined this single definition of blast risk. This bounding limit, however, provides a basis for a general comparison between NAPB-90 and TR-82. There were 829 whole counties which the TR-82 planning base defined as having at least one PGF point at 2.0 psi or more overpressure.

Using the same measurement for comparison of the two planning bases, there were 326 counties included in this risk definition in the NAPB-90 but which were not so identified in the TR-82 base, i.e., newly identified as at this risk level. Conversely, 190 counties at this risk level in TR-82 were no longer identified at this risk level in NAPB-90.

In sum, a total of 972 counties--a net increase of 136 counties--was identified at this risk level by NAPB-90.

Using estimated 1985 populations of only those PGF points in both planning bases which meet the 2.0 or more psi risk definition provide another comparison between the two bases:

	TR-82	NAPB-90
Population at 2 psi risk or greater	155.86 Million	129.74 Million
Population outside 2 psi risk area	85.79 Million	111.91 Million
Total 1985 U.S. population	241.65 Million	241.65 Million

As stated earlier, the reasons for this difference are numerous but can be summarized by stating that NAPB-90 was developed from a strategic targeter's force application viewpoint (how weapons would logically be used against targets). By contrast, the TR-82 planning base weapon employments deliberately created a "worst-worst" risk environment through the employment of all weapons in both air- and ground-burst modes for each aim point.

A secondary but important reason for this difference can be found in the weapon yields employed by both planning bases. The average assumed yield of all weapons used in NAPB-90 is slightly less than 1 megaton, reflecting the trend in Soviet (and in U.S.) strategic inventories toward smaller, more accurate weapons. By contrast, TR-82 employed then-current, high-yield Soviet weapons with yields as high as 20 megatons.

2. General Characteristics - The NAPB-90 and TR-82 planning bases have the following general characteristics in common, in opposition, or singularly:

TR-82	NAPB-90
° Risk assessment (see below) based upon "worst-worst" weapon employment	° Risk assessments based upon estimates of Soviet weapon employment
° Target priorities by class acknowledged but not used in application to preparedness programs (all risk areas assumed to be at equal risk)	° SAME; no change
° Illustrated publication showing maps with 2 psi blast envelopes (red) and high fallout risk counties (green)	° TO BE DETERMINED
° Planning base information made available for unlimited distribution to State and local governments and the public	° SAME; deployment to be determined

3. Target Classes - The NAPB-90 and TR-82 planning bases have the following target class characteristics in common, in opposition, or singularly:

TR-82	NAPB-90
° Selection of target classes based on the following criteria in descending order of priority:	° Selection of target classes based on recent data and the following headings:
-- U.S. Military Installations	-- Strategic Military Installations
-- NO COMPARABLE CLASS (included in target class above)	-- Non-Strategic, Other Military Installations and Bases
-- Military-Support Industry, Transportation, and Logistics	-- SAME, less Transportation and Logistics
-- Other basic industries and facilities that contribute significantly to maintaining U.S. economy	-- NO COMPARABLE CLASS
-- Population concentrations of 50,000 or more (Bureau of Census urbanized areas) not otherwise targeted	-- NO COMPARABLE CLASS
-- NO COMPARABLE CLASS	-- Ports
-- NO COMPARABLE CLASS	-- Petroleum Refineries
-- NO COMPARABLE CLASS	-- Political
-- NO COMPARABLE CLASS	-- Electric Power Plants
-- NO COMPARABLE CLASS	-- Chemical Industries
° Based on 1980 projections of Soviet capabilities; weapon employments developed considering active U.S. defenses, vulnerability, and time-sensitivity of targets; maximized target destruction; minimized weapons employed	° Virtually the same technique; used current-to-1990 Soviet weaponry; time-sensitivity of targets not a consideration
° Probable targets reviewed to eliminate isolated military and industrial facilities considered of marginal significance	° Editing of target classes done to conform with perceived Soviet strategic principles

° States given an opportunity to present justification for addition or deletion of targets they deemed at risk from nuclear attack effects; approved or disapproved at national level	° Virtually the same; methods of implementation to be determined

4. Assessments - The NAPB-90 and TR-82 planning bases have the following risk assessment characteristics in common, in opposition, or singularly:

TR-82	NAPB-90
° All weapons air burst to maximum ground range of 10.0 psi overpressure to attain worst case	° Weapons employed in accordance with perceived Soviet force application and targeting principles
° Blast envelopes depicted risk areas subject to a 50 percent or greater probability of receiving 2.0 psi overpressure or more	° Four direct effects risk levels identified (see Part 3.A., "Direct Effects Risk")
° Risk from thermal fire assigned to extent of 2.0 psi risk area	° Thermal and secondary blast fire fire risk identified (see Part 3.C., "Thermal and Secondary Blast Fire Risk")
° All weapons ground burst to maximize fallout radiation for worst case	° Fallout radiation risk determined from ground-burst weapons only
° High-risk fallout areas (whole counties) designated where there was 50 percent or greater probability of receiving an H+1 dose rate of 10,000 R or greater per hour for any of four seasonal winds (1975 publication only)	° Four fallout radiation risk levels identified (see Part 3.b., "Fallout Risk")

A. Soviet Strategic Policies - An initial study of Soviet military objectives, war-fighting scenarios, targeting strategies, and force applications provided the basis for many of the development procedures and policies of NAPB-90.

The study examined stated Soviet views on how they envisioned a nuclear war against the U.S. would be fought. Observations relevant to the development of NAPB-90 were adopted to the extent possible.

1. Soviet Nuclear War-Fighting Objectives - Almost all official pronouncements on this subject (culled from Soviet media) indicate that their main objective in a nuclear war is to attain "victory" over the enemy. Victory, by Soviet definition, is the destruction of the enemy government that started the war, and the disarming and neutralization of the enemy's military forces. Such a war is usually described as "imperialistic" forces facing "socialism" or "socialist coalitions."

In the development of the NAPB-90 target base, close attention was paid to frequent Soviet references to limiting damage to non-target resources of the enemy. This damage-limiting element of the Soviet nuclear war-fighting objectives significantly influenced the procedures used in making final NAPB-90 target aim point selections.

2. Soviet Nuclear War-Fighting Scenarios - Another important influence in the NAPB-90 development was how the Soviets perceived nuclear war would begin and how each scenario would effect their selection of potential targets. The Soviets see three possible scenarios as most likely to start a nuclear war:

- Preemptive attack on strategic warning of enemy attack;
- Launch on tactical warning; and
- Attack in retaliation for being attacked.

Under all of these scenarios, Soviet targeting objectives remained the same. The final NAPB-90 was, therefore, designed to reflect these objectives and is not a prediction of the results of any war-fighting scenario envisioned by the Soviets or by U.S. planners. The decision to make the NAPB-90 planning base scenario-independent is reinforced by the fact that Soviet targeting priorities, as with their objectives, "remain essentially the same" regardless of the a priori scenario under which weapons would be employed.

It was also significant to note that should the Soviets be faced with their scenario which calls for a retaliatory strike after being attacked, they do not see such a strike as "...designed simply to inflict an unacceptable level of damage, the threat of which should have deterred the enemy in the first place."

As to how long a nuclear conflict would last, the Soviets believe that a war "...is more likely to begin with a crisis period in which both sides would ready their forces and take measures to protect their economics (sic) and population." Also, most Soviet authorities see a conventional war phase preceding a nuclear war, with escalation into the use of nuclear weapons as "inevitable."

These Soviet perceptions on the conditions under which nuclear war would start were important factors in determining NAPB-90 planning policies and assumptions to mitigate the nuclear effects risk environments that might result.

3. Soviet Targeting Strategies - Publications carrying speeches and articles by top Soviet military and political leaders make clear that the targets of the Soviet "Strategic Nuclear Forces" reflect their objectives discussed above. Specific NAPB-90 target selection (discussed at length elsewhere in this paper) is based on these Soviet target selections. An important point in their selections is that population, as such, is not specified as a Soviet target.

4. Soviet Force Application - The Soviet application of their nuclear targeting strategy follows these force-application principles, most of which influenced the development of the NAPB-90 target base:

- Destroy "most threatening" enemy forces;
- Select "main links and nodes" in target "sets" (such as the National Command Authority);
- "Do not destroy large areas or create radioactive deserts;"
- Use minimum weapon yields ("explosive power") necessary so as not to drastically "overkill" the target;
- "Prepare to strike most important targets twice;" and
- "It is not possible, nor desirable, nor necessary to attack and destroy all targets (in the operational zone)."

These force-application principles (among many more) agree with Soviet doctrines and strategies discussed above. The "enemy" is to be defeated through destruction of its military forces and by preventing their reconstitution.

B. NAPB-90 Target Selection Considerations - Ten target classes containing 6,139 aim points were included in an initial target set as follows:

Target Class	Aim Points
° ICBM silos and launch control centers	1,228
° Other Air Force facilities and complexes	199
° Other Army facilities and complexes	159
° Other Navy facilities and complexes	110
Total other military facilities and complexes	(468)
° Key military-support industries	325
° Political infrastructure	44
° Ports and port facilities	106
° Petroleum refineries	242
° Electric power generating facilities	1,632
° Chemical industry facilities	2,094
Total Initial Aim Points	6,139

The initial target set served as a basis for aim point editing to meet Soviet strategic objectives.

1. Military Aim Point Editing - In the ICBM silos and launch control center class, all aim points included in the Titan missile complexes at Little Rock Air Force Base (AFB), Little Rock, Arkansas; McConnell AFB, Wichita, Kansas; and Davis Monthan AFB, Tucson, Arizona, were eliminated. All of these missile complexes are being or will be phased out within the 1985-1990 period and will, therefore, cease to be potential targets.

2. Editing of Industrial Aim Points - Over 60 percent of the original aim points listed above occurred in three target classes: petroleum refineries, electric power generating facilities, and chemical industry facilities. This large number made it obvious that these classes would require extensive editing since they covered the majority of industrial facilities in each class, a large number of which were small industries not considered significant enough to be included for national damage assessment purposes.

a. Editing of Petroleum Refineries Class - For the editing of the petroleum refineries class, no refinery with a capacity of less than 75,000 barrels per day was considered a potential target. The remaining industries in the class were targeted. It was assumed that a rank order degradation of refinery capacities to an assured level of 75 percent damage or destruction would constitute effective neutralization of the industry without its total destruction.

b. Editing of Electric Power Generating Facilities Class - For the editing of the electric power generating facilities class, facilities were ranked ordered by generating capacity. These site capacities were then selectively targeted until an assured 75 percent degradation was achieved. This level of degradation was assumed to effectively neutralize the capability of

the electric power grid network to transmit or exchange generated power, and also did not totally destroy the industry as a whole.

c. Editing of Chemical Industry Class - The basis for editing the chemical industry class was a Stanford Research Institute study done for the Office of Civil Defense in 1968. This study was an assessment of the severity of damage to the chemical industry as a result of nuclear war. It indicated that the worst-case scenario for the chemical industry as a whole would be the damage or destruction of those chemical facilities furnishing "basic" chemicals--chemicals necessary or common to a chemical industry itself as well as to other industries. These basic chemical industries include those which manufacture alkalines and chlorines, industrial gases, inorganic and organic chemicals, and pigments (grouped under the Standard Industrial Code 281 category). Aim points for this category were selected and targeted to provide an assured neutralization of all other chemical industries. These aim points replaced the initial chemical class listing.

C. NAPB-90 Weapon Inventory File - The Soviet strategic weapon arsenal used as the initial NAPB-90 weapon inventory file was developed from a Soviet inventory published in a report by the Congressional Budget Office (CBO) titled "Counterforce Issues for U.S. Nuclear Forces," January 1978. The report projected Soviet strategic forces through 1985. Since NAPB-90 is intended to reflect a threat planning base through 1990, the CBO data were selectively modified to reflect probable changes in currently deployed Soviet strategic forces through 1990. Table C-1 shows the initial CBO data together with the predicted changes. Notes on these and other changes reflect 1990 Soviet strategic weapon deployments reflected in a Department of Defense report, "Soviet Military Power," fourth edition, April 1985.

Table C-1. Established Soviet Military Forces, 1985

Launch Vehicle	Number in Inventory	Warheads Each	Warheads Total
INTERCONTINENTAL BALLISTIC MISSILES			
SS-11 [1]	420	1	420
SS-13 [2]	60	1	60
SS-17 [3]	150	4	600
SS-18 [4]	308	10	3030
SS-19 [5]	360	6	2160
TOTAL ICBM	1298		6300
SUBMARINE-LAUNCHED BALLISTIC MISSILES			
SS-N-6/8 [6]	600	1	600
SS-N-17/18 [7]	300	3	900
TOTAL SLBM	900		1500

Notes on projected 1990 force posture are found on next page.

1/ Mods #2 and #3 are principally deployed; 420 launch vehicles total.
2/ No change from 1985 deployment posture.
3/ Mod #3 deployed; 150 launch vehicles total.
4/ Mod #4 deployed; 308 launch vehicles total with 10 warheads each.
5/ Mod #3 deployed; 360 launch vehicles.
6/ For the SS-N-6, Mods #2 and #3 deployed; Mod #3 will have 2 warheads each. For the SS-N-8, Mod #2 deployed.
7/ The SS-N-17 had limited deployment. For SS-N-18, Mod #3 deployment is assumed; will have 7 warheads each.

New Vehicles: ICBMs: SS-X-24 and SS-25 have limited deployment.
SLBMs: SS-N-20 deployed; 6 to 9 warheads each. SS-NX-23 to be deployed on Delta IV class submarines.

Although standard weapon employment procedures were followed, closer attention was paid to the assumed weapon yields which could influence the extent and degree of potential risk, as well as the probability of that risk occurring in a given area than to the weapon delivery system employed.

While all actions were taken to ensure a realistic representation of Soviet strategic nuclear force applications, it should be emphasized that NAPB-90 does not attempt to predict the specific weapons applications of Soviet strategic planners. The structure of the final Soviet weapon systems used has, therefore, little relevance to the planning purpose of the base, i.e., to depict potential nuclear weapons effects.

D. Targeting Considerations - It was pointed out earlier that one of the principal differences between the TR-82 planning base and NAPB-90 lay in the manner in which weapons were employed against potential targets. NAPB-90 aim points were attacked using estimates of Soviet strategic targeting procedures, i.e., Soviet views on nuclear weapons effects and target vulnerabilities. The following discusses targeting considerations employed by NAPB-90:

1. Height of Weapon Detonation - A nuclear weapon generates very large blast overpressures. The range or extent of this blast overpressure is closely related to the height of burst (HOB) of the weapon. Nominally, this is referred to as an "optimum HOB" since it represents the height chosen by the strategic planner to maximize desired levels of overpressures over the widest possible area. A particular overpressure level is chosen to assure the desired damage or destruction of the target.

The optimum HOB selected for NAPB-90 "soft" or area targets (such as a large industrial facility) normally precludes the weapon's fireball from reaching the ground. In these cases, the weapon can be said to be "air-burst."

When the fireball in whole or in part touches the ground, the weapon is considered "surface-burst." NAPB-90 employed surface burst weapons against "hard" or point targets (such as missile siloes).

In both cases, NAPB-90 weapons were employed at an altitude which assured generation of the overpressure believed necessary to damage or destroy the potential target.

2. Target Surface Characteristics - NAPB-90 weapon employment considered the influences on the extent of overpressure generated by weapon detonations--ranges significantly influenced by the surface characteristics of the target. These characteristics have a marked effect on the range of overpressures, each surface characteristic having its own optimum HOB to maximize particular psi overpressures. The reasons for these differences are discussed below.

- Ideal surfaces are perfectly flat terrain and reflect all of the overpressure (or "mechanical") and thermal (or "heat") energies of the weapon, i.e., nothing inhibits the spread or range of these effects. Ideal surfaces are used as a hypothetical "base case" for weapon characteristics. No such surfaces exist on earth.

- Near-ideal surfaces are "reasonably" flat terrains and reflect most of the mechanical and thermal energy of the weapon. Ice, hard-packed snow, water, and frozen tundra are examples of this type of surface. Inhibitions of generated energies on this type of surface are small.

- Non-ideal surfaces are flat to uneven terrains which can interact with the thermal energy of the weapon through ignition of surface material and the generation of large amounts of dust and debris. The dust and debris absorb some of the thermal energy and heat the air above normal temperature around the target. Together with the dust, this higher air temperature "pocket" interacts with the reflection of the blast wave off of the surface and a "precursor" or leading pressure wave is formed. The result is that the range of mechanical overpressures is reduced and the dynamic or "punch" pressure is increased.

Weapon effects on near- and non-ideal surfaces can be further influenced by types of soil, the degree and density of vegetation, and the amount of moisture present in the area. All of these additional characteristics inhibit the range of overpressures. Strategic planners refer to such surface characteristics as "grey areas" in calculating optimum HOB's.

3. Target Vulnerability - The choices of weapons employed by NAPB-90 were based upon the weapon HOB necessary to maximize selected overpressures. The overpressure selected was based upon the vulnerability of the target and the desired level of damage or destruction to be achieved. The "soft" targets discussed earlier are generally vulnerable to low levels of overpressure (some industrial plants will sustain substantial damage at as low as 3.0 psi). "Hard" targets require very much higher overpressures to effect damage or destruction.

As a general rule, then, a soft target in the NAPB-90 listing was attacked with an air-burst weapon to achieve the widest possible range of the desired blast overpressure and employment of the weapon did not generally result in

the creation of fallout (see a discussion of this in Part 3.B., "Fallout Risk"). The converse applied to very low or surface-burst weapons which NAPB-90 employed against hard targets.

4. Probability of Damage or Destruction - A strategic planner works to assure that a chosen target will be damaged or destroyed. If all weapon employment considerations are correct and the weapon detonates at the aim point, damage or destruction will (theoretically) be assured. Weapon systems, however, are not 100 percent reliable. To add assurance that the goal will be met, NAPB-90 weapon employment considered two other factors:

- The accuracy of the weapon - NAPB-90 aim points represented the desired point of weapon detonation (nominally, the "desired ground zero" or DGZ). Weapon guidance systems, however, will usually deviate from this DGZ by a predictable distance and probability. The amount of this deviation, measured in feet from the DGZ, represents the radius of a circle around the DGZ within which the weapon can be expected to impact a warhead at least 50 percent of the time. This deviation is called the "circle error probable" or CEP of the weapon. NAPB-90 weapon employed considered CEP's to determine the HOB of the weapon to ensure that desired overpressure ranges would reach the target.

- The probability of arrival of the weapon - This is an expression of the combined probability the launch vehicle will (1) have a successful launch; (2) follow its programmed trajectory or course; and (3) its weapon detonates upon arrival at the target. NAPB-90 considered the probability of arrival of the weapon to determine if multiple weapons were needed to ensure destruction of the target.

E. Other NAPB-90 Considerations

1. "Nuclear Winter" - In 1984, a group of scientists produced a study which hypothesized that a large-scale attack on the U.S., principally against urban areas, would result in an injection into the atmosphere of an inordinate amount of smoke and soot from attack-generated fires. Their study (called "TTAPS" after the initials of the co-authors) predicted that a severe drop in temperature or a "Nuclear Winter" would result from the sun's energy being absorbed by the cover of smoke and soot. The study produced widespread interest within the scientific community, the media, and among the general public.

In the intervening time since its publication, a large number of scientists (including some of the original authors) and scientific organizations (such as the National Academy of Sciences) have acknowledged that there are uncertainties connected with the original hypothesis. Some investigations made since the TTAPS study have suggested that the amount of smoke and soot produced may be much less than that predicted by the study. Weather conditions, such as cloud cover and turbulence due to uneven smoke and soot distributions, may accelerate the "cleansing" of the atmosphere more rapidly

than originally suggested. The hypothesis also depends on a number of broad assumptions of local weather conditions, the distribution pattern of the smoke and soot in the upper atmosphere, the number and location of targets that will be attacked, the amount of available fire fuel in the target area which will ignite and burn, and the like. The current trend in both Soviet and U.S. warheads toward more accurate, low-yield weapons designed to limit collateral damage around a target has also suggested the effects may be less severe than those suggested by the study.

Until these uncertainties are resolved, the concept of a "nuclear winter" as predicted by the TTAPS study does not justify a shift in current civil preparedness planning and policy. Until more research and study are carried on this potential phenomenon, such an hypothesis cannot be incorporated into a civil preparedness planning base.

In the interim, NAPB-90 provides an objective analysis of the known potential nuclear attack effects.

2. Electromagnetic Pulse (EMP) - A secondary but nevertheless important effect of any nuclear detonation appears as an electromagnetic pulse. It is another form of energy released by the weapon in the electromagnetic radiation spectrum. At the high end of this spectrum, the weapon generates initial nuclear radiation (X-rays and gamma rays) at the moment of explosion; thermal radiation energies given off by the explosion are in the infrared and ultraviolet frequencies of the spectrum; and the electromagnetic pulse (composed of electrons) covers the lower end of the spectrum. The frequencies in this part of the spectrum are among those used in electric power generation, many forms of radio and television transmission, and military communications and detection systems.

The EMP effect resulting from a nuclear detonation within the earth's atmosphere is generally not significant, but if high yield weapons are detonated outside of the atmosphere, an efficient conversion of nuclear energy into the eletromagnetic frequency range occurs. This energy can cover a very substantial area and has the capability of "coupling with and affecting the operation of electrical and electronic equipment which has not been protected. Examples of EMP damage observed during the atmospheric test programs ranged from damaged cables due to "arc-overs" to the false tripping of street light systems many hundreds of miles from the detonation point. Similar results have been observed for modern, sophisticated equipment exposed to simulated EMP. Such equipment, if not otherwise protected, has a very high probability of becoming inoperative at even very low levels of EMP. In general, the more modern and sophisticated the equipment, the higher the potential for EMP degradation.

These and other concerns about the potential EMP damage to electric power and communications systems certainly demand the attention of emergency planners. Preparedness measures to mitigate the blast, fire, and fallout risks outlined by NAPB-90, as well as long-term measures to maintain life support, must consider the possibility of additional burdens imposed by EMP before, during, or after a nuclear attack.

The effect of the potential use of nuclear weapons to deliberately create an EMP effect is, however, considered to be a war-fighting option. Since NAPB-90 is scenario-independent and does not purport to predict how a nuclear war would be fought, EMP must be considered outside its scope.

3. Strategic Defense Initiative (SDI) - In 1983, the Administration proposed that a strategic defense be initiated to explore the feasibility of providing a defense against ballistic missiles. Research was begun on technologies which could support a capability to engage and destroy hostile ballistic missiles during four phases of the missiles' flight paths:

- The boost or launch phase while the missile is accelerating;
- The mid-course or post-boost phase when the propulsion rockets of the missile have separated from the warhead;
- The mid-course phase when the warhead goes through the topmost section of its ballistic path; and
- The terminal phase when the warhead is in its final descent toward the target.

In short, SDI research is exploring the feasibility of a multi-layered space defense shield along the entire spectrum of the flight of a ballistic missile. What configuration this multi-layered approach will take if employed, is not now known. Hence, the exact relationship of SDI and the civil preparedness program cannot be determined. A deployed strategic defense probably will not be able to determine--in the boost and mid-course phases--which U.S. targets had been spared by the destruction of a single missile. On the other hand, this relationship could be surmised when terminal phase defenses have been emplaced to protect specific targets. For targets not protected by a terminal defense, potential targets following activation of the strategic defense could not be realistically determined.

For the foreseeable future, then, planning against the potential effects of a nuclear war must be based on current and predicted offensive nuclear forces which could be employed against U.S. targets.

F. References - The following publications were used in the development of NAPB-90. Except where noted, all are available in the public domain:

- "The Effects of Nuclear War," Office of Technological Assessment, Congress of the U.S., 1979.
- "Radiological Factors Affecting Decision-Making in a Nuclear Attack," National Council on Radiation Protection and Measurements, Report No. 42, November 1974.
- "High Risk Areas for Civil Nuclear Defense Planning Purposes," FEMA Publication TR-82, September 1979.

° "The Effects of Nuclear Weapons," U.S. Atomic Energy Commission and the Department of Defense, February 1977.

° "Critical Industry Repair Analysis: Electric Power," O. Fendald, Advance Research, Inc., Cleveland, Ohio, April 1963.

° "Studies of Post-Disaster Economic Recovery," L. J. Hill, Oak Ridge National Laboratory, Oak Ridge, Tennessee, June 1985; report prepared for FEMA under an Interagency Agreement with the U.S. Department of Energy.

° "Development of Rapid Shutdown Techniques for Critical Industries," F. R. McFadden, C. D. Bigelow, Stanford Research Institute, Menlo Park, California, January 1966.

° "FEMA Attack Environment Manual," Civil Preparedness Guide Series 2-1, Chapters 1 through 9, Federal Emergency Management Agency, 1982 (some information taken from 1985 update drafts). (Note: CPG 2-1 chapters contain extensive topical bibliographies which are not repeated here.)

° "Casualties Due to Blast, Heat, and Radioactive Fallout From Various Hypothetical Nuclear Attacks on the U.S.," W. Daugherty, B. Levi, F. von Hippel, Center for Energy and Environmental Studies, Princeton, New Jersey, September 1985.

° "Damage to the Basic Chemical Industry from Nuclear Attack and Resulting Requirements for Repair and Reclamation," final report prepared for Stanford Research Institute, URS Systems Corporation, 1968.

° "Nuclear Winter and Deterrence: Coming in From the Cold," Dr. John M. Weinstein, National Defense Magazine, October 1985.

° "Nuclear Battlefields," W. M. Arkin, R. W. Fieldhouse, Institute for Policy Studies, Ballinger Publishing Company, 1985.

° "Calculating the Vulnerability of Synthetic Polymers to Autoignition During Nuclear Flash," R. Hickman, T. Reitter, Lawrence Livermore National Laboratory, March 1985.

° "Soviet Military Power," U.S. Department of Defense, Fourth Edition, April 1985; Fifth Edition, March 1986.

° "Counterforce Issues for U.S. Strategic Nuclear Forces," Congressional Budget Office Report, 1978.

° "Nuclear Winter -- Uncertainties Surrounding the Long-Term Effects of Nuclear War," U.S. General Accounting Office Report to the Congress, March 1986.

- "Less Drastic Theory Emerges on Freezing After a Nuclear War," James Gleick, New York Times news article, June 22, 1986.

- "An Assessment of Protection Factors for FEMA-Designated Fallout Shelters," Dr. J. T. McGahan, Science Applications International Corp., final report to the Defense Nuclear Agency, January 1986.



A. Direct Effects Risk

1. General Overview - Blast overpressures generated by a nuclear weapon detonation present the greatest risk to human life and health in a nuclear effects environment because achieving effective protection is so difficult. The destruction, death, and injury that can result from the blast generated overpressures of modern nuclear weapons are awesome compared to those from the atomic weapons used against Hiroshima and Nagasaki, Japan, in World War II. Although current thermonuclear weapons have diminished in yields (principally because of greater accuracy), the power generated is still magnitudes above that released by the earlier weapons.

Protective measures against direct effects of weapons have been researched and are possible but generally impractical due to the enormous expenditures entailed in the construction of a comprehensive blast shelter system. Over the years, proposals to initiate a combined blast and fallout shelter program have been submitted to the Congress but not accepted. In some areas close to the point of detonation (which can never be predicted accurately) even extensive protective measures may be inadequate and, even if successful in mitigating initial effects, may be insufficient to support continued habitation of the area.

Fire generated by the thermal pulse of the weapon and by damage-induced ruptures in gas and electric lines also could present a formidable risk for survivors close in to the target aim point. The fire risk is discussed in C., below.

Even in areas far enough from the point of detonation to escape severe damage, the population still faces unique survival problems to protect their lives and continued health in the direct effects environment.

2. Extent of Risk - The extent and range affected by this risk are determined by:

- The altitude at which the weapon is detonated (see the discussion of this in Part 2.D., "Targeting Considerations"). The altitude at which the weapon is detonated determines the range of given overpressures.

- The yield of the weapon. The range of a given blast overpressure increases with the cube root of the weapon yield in kilotons and is directly correlated to the height of burst.

- The accuracy of the weapon (see the discussion of this in Part 2.D., "Targeting Considerations"). Weapons used in NAPB-90 were assumed

to have extremely small CEP's. CEP's, therefore, have little effect on the extent of the damage area and influence only the location of the damage.

- The probability of arrival of the weapon (see the discussion of this in Part 2.D., "Targeting Considerations"). Weapons used in NAPB-90 were assumed to have a probability of arrival of 66 percent or greater.

3. Statistical Overview - NAPB-90 defines the potential risk from nuclear weapon blast overpressures as the total area affected by 0.5 pound per square inch (psi) or more. This represents 727,112 square miles of U.S. territory with an estimated resident population of 175.11 millions. Approximately 66.54 million people, therefore, are not considered to be at risk from blast overpressures although some of this number (approximately 2.47 million) reside in areas immediately outside of the 0.5 psi boundary and may experience low levels of blast overpressure (i.e., less than 0.5 psi). Since NAPB-90 does not target population per se, the persons affected by blast overpressures reside in areas which are peripheral to or collocated with potential military and industrial targets (see Part 2.B., "Target Selection").

The magnitude of this potential risk is represented with maps and statistics in Annex A.

4. Methodology Employed - The selection and methodology employed for arriving at potential aim points included in NAPB-90 are discussed in detail in Part 2., "Project Development," and will not be repeated here. In general, direct effects risk areas are the result of considerations discussed in Part 2.D., "Targeting Considerations." Specific criteria used to select critical psi demarcations are included in discussions of these areas.

NAPB-90 defines four levels of potential risk from blast overpressure. Each definition is driven by the degree of influence a specific blast overpressure has on the continued life and health of the resident population. In this context, the following considerations were used in determining the degrees of direct effects risk:

- The severity of short-term risk posed by the blast wave itself in terms of its potential to kill or injure directly, or through damage or destruction of homes and buildings. This short-term risk may include the immediate effects of the weapon's thermal pulse.

- The potential long-term severity of the risk to survivors within the area by entrapment in damaged or destroyed buildings and by fires created by thermal pulse generated and damage-caused ignitions. Fire risk is discussed in C., below.

- The kind, degree, and practicality of in-place and/or crisis-generated preparedness measures necessary to mitigate initial blast, thermal pulse, and initial reation risks as well as measures necessary to assure continued life support for long-term habitation in the area. Also included in this consideration is the cost of such measures in total effort, time of preparation, and efficacy.

The potential risk from initial radiation released at the time of detonation is considered by NAPB-90 to be reciprocal with the risk from blast generated overpressure. As an example, at a distance of one mile from a one megaton air-burst detonation, initial radiation would probably prove fatal to a large portion of persons in the area even if they were shielded by 24 inches of concrete. These same people would simultaneously be exposed to blast over-pressures of from 50 to 60 psi. Thus, the specific level of risk from initial radiation is difficult to define since population at risk to lethal levels of initial radiation is at double jeopardy from blast overpressure.

a. Very High Direct Effects Risk

(1) Definition - A Very High Direct Effects Risk Area is defined as the area surrounding a target aim point which has the potential to experience blast overpressures equal to or greater than 10.0 pounds per square inch (psi) from a nuclear weapon detonation.

(2) Criteria - In a Very High Direct Effects Risk Area death or severe injury from blast overpressure is certain without specially constructed protection against the blast wave and initial radiation. Survivors in this area might also face probably fatal fires generated by the thermal pulse of the weapon as well as damage-caused ignitions from ruptured gas and electric lines. This 10.0 psi limit marks the approximate median (50-50) point of lethal overpressure for persons inside homes as well as the threshold (beginning point) of possible lung damage. Beyond this demarcation, probable death and severe injury increase as overpressures increase exponentially toward the point of detonation.

While blast effects could be mitigated through specially constructed blast shelter, shelter occupants would also require protection from highly debilitating if not lethal levels of ionized radiation (neutrons and gamma rays) produced at the instant of the detonation of weapon. This initial radiation is extremely more difficult to protect against than fallout radiation produced by the fission reaction of the weapon.

In short, potential Very High Direct Effects Risk Areas are extremely dangerous for the continued protection and maintenance of human life.

(3) Overview - The total potential Very High Direct Effects Risk Areas in the U.S. cover approximately 46,352 square miles, with a resident population of 47.25 millions. Of the total U.S. area and population defined by NAPB-90 at risk from direct effects, 1.3 percent of the land area and 27.0 percent of the population fall under this risk definition. As a population group, those in potential Very High Direct Effects Risk Areas represent 19.6 percent of the total population of the U.S.

b. High Direct Effects Risk

(1) Definition - A High Direct Effects Risk Area is defined as the area around a target aim point which has the potential to experience

blast overpressures from a nuclear weapon detonation of equal to or greater than 5.0 psi but less than 10.0 psi.

(2) Criteria - A High Direct Effects Risk Area is a distinctly hazardous nuclear effects environment. Within this area lies the demarcation point of the median (50/50) probability of injury to persons within homes (approximately 7.0 psi). This is illustrative of the need for population protection measures of a prodigious nature in this area (measures which may still prove to be insufficient and impractical). Depending upon the type of construction, a large majority of homes within this area could be severely damaged or totally destroyed. Continued habitation in the area --even if survival of the initial blast overpressures were attained--would probably be impractical.

(3) Overview - The total potential High Direct Effects Risk Areas in the U.S. cover approximately 49,896 square miles with a resident population of 32.19 millions. Of the total U.S. area and population defined by NAPB-90 at risk from direct effects, 1.4 percent of the land area and 18.4 percent of the population fall under this threat definition. As a population group, those in potential High Direct Effects Risk Areas represent 13.3 percent of the total population of the U.S.

c. Medium Direct Effects Risk

(1) Definition - A Medium Direct Effects Risk Area is defined as the area surrounding a target aim point which has the potential to experience blast overpressures from a nuclear detonation of equal to or greater than 2.0 psi but less than 5.0 psi.

(2) Criteria - Unprotected and poorly protected populations in a Medium Direct Effects Risk Area have a sure probability of becoming injured or killed from either the dangers created by the blast overpressure or from the thermal pulse of a weapon. The impact lethality threshold, or the overpressure at which death could result from a body thrown by the blast, occurs within this area at approximately 3.3 psi. At approximately 2.3 psi and up, the likelihood of skull fractures increases from the same phenomenon and shattered glass and other debris impelled by the blast can be very dangerous and potentially fatal.

This area poses a risk to populations due to direct structural damage of homes and buildings. Persons caught outdoors when the detonation occurs may receive potentially severe and possibly fatal burns from the thermal pulse of the weapon. Without a detailed analysis of the specific characteristics of each area in this risk category, it must be assumed that there is a very high potential for fires that could result from the thermal pulse of the weapon or from damage-caused ignitions (see C., below). Protective measures to mitigate the immediate effects within this area are possible but time consuming and complex. Depending on the type of construction, homes and other buildings in this area would suffer moderately high to severe damage and may not be repairable. Morever, continued habitation of undamaged or repaired homes may prove difficult and impractical except for emergency reasons. Long-term preparations to sustain surviving populations may also

have to take into consideration the potential lack of water pressure or electricity, as well as the complete failure of other vital community services. Finally, if downwind from a ground-burst weapon, the risk from fallout radiation may exacerbate and override the direct effects risk in this area.

(3) Overview - The total potential Medium Direct Effects Risk Areas in the U.S. cover approximately 151,535 square miles, which have a resident population of 50.3 millions., Of the total U.S. area and population defined by NAPB-90 as at risk from direct effects, 4.3 percent of the land area and 28.7 percent of the population fall under this risk definition. As a population group, those in potential Medium Direct Effects Risk Areas represent 20.8 percent of the total population of the U.S.

d. Low Direct Effects Risk

(1) Definition - A Low Direct Effects Risk Area is defined as the area surrounding a target aim point which has the potential to experience blast overpressures from a nuclear detonation of equal to or greater than 0.5 psi but less than 2.0 psi.

(2) Criteria - Blast overpressures in a Low Direct Effects Risk Area are not lethal in themselves, but serious injury or death can occur from flying debris if protection measures are not taken. In addition, the thermal pulse of the weapon in this area could result in significant first and second degree burns on exposed skin. Damage to homes and other buildings could range from low to moderately high depending upon the type of construction but would, generally, be limited to repairable damage. Repair of the area for continued long-term habitation could be a serious problem. Small but controllable fires are possible through thermal pulse ignitions of curtains, furniture, and other light flammable substances in and about homes. If uncontrolled initially, however, fires in this area might become a significant risk.

If downwind from a ground-burst weapon, this area could, within a short period of time, receive a significant amount of fallout radiation requiring additional protective measures.

(3) Overview - The total potential Low Direct Effects Risk Areas in the U.S. cover approximately 479,329 square miles, which have a resident population of 45.37 millions. Of the total U.S. area and population defined by NAPB-90 as at risk from direct effects, 13.5 percent of the land area and 25.9 percent of the population fall under this risk definition. As a population group, those in potential Low Direct Effects Risk Areas represent 18.8 percent of the total population of the U.S.

B. Fallout Radiation Risk

1. General Overview - The risk to U.S. population from gamma radiation given off from fallout particles produced by ground burst nuclear weapons is vast and far-reaching. None of the continental U.S. land area can be considered categorically secure from this risk. The two types of fallout from

a ground burst detonation are "early" (within 24 hours of the detonation) and "delayed" (after 24 hours of the detonation). Approximately 80 percent of the total radioactivity generated by a ground-burst weapon will be in the form of early fallout, with the remaining 20 percent reaching earth in the form of delayed fallout hundreds or thousands of miles from the point of detonation of the weapon. Heavier radioactive particles constitute the bulk of early fallout and fall closer in to the detonation point, while smaller, lighter particles are carried downwind eventually to fall earthward as delayed fallout. Delayed fallout, therefore, can cause radioactive contamination far beyond the range of the direct effects of the weapon detonation producing it. Given seasonal changes in weather patterns plus unpredictable local occurrences such as rain and showers, fallout must be regarded as a potential risk to all U.S. land areas.

The risk derives from human exposure to the gamma and beta radiation emitted by the fallout particles. Of these two types of radiation, protection from gamma rays is the more difficult to achieve since it requires extensive shielding ("mass") to reduce the radiation.

Gamma radiation is measured in units of roentgen (R) energy. The risk to human health and life is the amount of such energy absorbed by the body over time, called the "total dose." In most cases, a very high percentage of the total dose received will occur within the first hours after fallout arrival. In assessing the degree of risk from fallout, the total dose accumulated during a 1-week period provides an efficient standard of measurement. Table B-1 shows this and other exposure criteria for estimating the risk to human life and health from gamma radiation exposure.

Table B-1. OUTCOMES OF EXPOSURE TO GAMMA RADIATION

Persons Needing Medical Care	Accumulated R Dose Within: One Week	One Month	Four Months
NONE	150	200	300
SOME (5% may die)	250	350	500
MOST (50% may die)	450	600	---

NAPB-90 based threat assessments on the potential effect of fallout radiation on the resident population of an area over a period of 1 week following the deposition of fallout and on the efficacy of various levels of shelter protection to mitigate such exposure. While Table B-1 is useful as a guide for judging potential acute radiation penalties in a nuclear attack environment, longer term biological effects should also be considered. Using shelter offering the highest protection possible in any fallout area to limit exposure to the lowest possible level will reduce the risk of medical care for acute radiation sickness as well as the risk of longer term biological effects. In NAPB-90, assessments of longer term effects for additional survivor deaths from radiation-induced cancers as well as deaths in future progeny caused by genetic damage were calculated for a range of total exposures. These

assessments were based on the assumption that exposures in a post-shelter environment (beyond 1 week) were the same as the exposure in the first week, i.e., the 1-week shelter exposure was essentially doubled to account for exposures over the longer term from remaining lower level radiation.

Estimations of potential increases in cancer deaths due to radiation exposures were based on work done by Dr. Warren Sinclair, President of the National Council on Radiation Protection and Measurements. He calculated that the cancer deaths resulting from exposures to 100R or more (but less than lethal) would be 3 percent per 100 person-roentgen (a 100 person-roentgen exposure would result if each of 100 persons were exposed to 1 roentgen, or if 50 people were exposed to 2 roentgens each, etc.). To calculate the cancer deaths for lower exposure levels, it was assumed that the percentage would decrease linearly from 3 percent per 100 person-roentgen at 100R exposure to 1.25 percent per 100 person-roentgen at 1 R exposure. Table B-2 shows these and other calculations made for other exposure levels.

The basis for data on genetic damage affecting future generations was taken from a document written by Sir Edward Pochin, former President of the International Commission on Radiation Protection as well as the British representative on the United Nations Scientific Committee on the Effects of Atomic Radiation. Dr. Pochin estimated that the increase in future deaths due to genetic damage would be 0.35 percent for each 100 person-roentgen. Calculations for other exposure levels were made accordingly as shown on Table B-2.

TABLE B-2. CANCER AND GENETIC CONSEQUENCES OF ONE-WEEK RADIATION DOSES

One-Week Acute R Dose	Assumed Total R Dose	Percent Cancer Deaths	Percent Genetic Deaths
6R	12R	0.18	0.04
12R	24R	0.40	0.08
15R	30R	0.53	0.10
30R	60R	1.40	0.21
38R	76R	2.00	0.27
50R	100R	3.00	0.35
75R	150R	4.50	0.53
100R	200R	6.00	0.70
150R	300R	9.00	1.10
188R	376R	11.00	1.30
200R	400R	12.00	1.40
250R	500R	15.00	1.80
300R	600R	18.00	2.10
375R	750R	23.00	2.60
500R	1000R	30.00	3.50
600R	1200R	36.00	4.20

These calculations are reflected in tables illustrating the consequence of shelter use for each of the risk levels discussed below.

2. Extent of the Risk. Residual radiation comes from the radioactive by-products of a nuclear detonation. The radioactive elements created by the detonation are joined with materials scoured from the crater of a ground burst weapon to form "fallout particles" which give off gamma radiation (as well as other less harmful forms of radiation). The extent of the risk portrayed by NAPB-90 was determined by:

- The fission-fusion ratio of the weapon. In a nuclear detonation, over 300 different radioactive isotopes are formed by the atomic fission ("splitting") of the uranium or plutonium used in the weapon. Atomic fusion ("joining") actions within the weapon create no harmful radioactive substances. The amount of fission products produced by the weapon is a function of the percentage of the weapon yield which results from fission. The fission-fusion ratio of an NAPB-90 weapon was assumed, for planning purposes, to be a 50-50 ratio (although fission-fusion ratios higher and lower than 0.5 are possible).

- The amount of fallout produced. Each megaton of fission energy yield (equivalent to 1 million tons of TNT explosive force) produces about 125 pounds of radioactive by-products. At the same time, a surface burst weapon vaporizes and draws upward an enormous amount of surface material (weighing up to 500,000 tons depending upon the weapon yield). This vaporized material, as it cools, combines with the fission by-products of the explosion to form fallout particles. NAPB-90 fallout risk was determined by analysis of weapons employed in a ground-burst mode.

- The altitude at which the weapon is detonated. (See the discussion of this in Part 2.D., "Targeting Considerations"). Generally, the more the fireball of a surface-burst weapon makes contact with the ground, from merely touching the surface to below-ground detonations, the more ground material will be lofted and be available for combination with fission by-products to produce fallout particles. Weapons employed by NAPB-90 in this mode were also analyzed for contribution to the fallout risk.

- The distribution of fallout. The wind direction and speed in the layers of the atmosphere up to the height reached by the mushroom cloud determines the area coverage of fallout. The height of the cloud is a function of the heat generated by the weapon yield. For very large weapons the cloud could reach 15 to 20 miles in altitude. The cloud drifts away from the target in relation to the speed and direction of the winds in each atmospheric layer through which the cloud has risen. Distribution of the fallout particles to the ground is a function of wind speed and gravity. The heavier particles will fall first, while lighter particles may be carried hundreds or thousands of miles from the target area before returning to earth. (See 4., below, for a discussion of the methodology employed by NAPB-90 to determine the distribution of the fallout risk.)

° The decay rate of the radioactivity in fallout. Each of the radioactive substances produced by fission exhibits a continuous and regular decrease or decay in the amount of radiation it gives off over time. The rate of decay is expressed as the "half-life" of the element, or the amount of time necessary for its radiation intensity to be reduced by one-half the original intensity. Two fission by-products are illustrative: the half-life of radioactive iodine-131 is 8 days, while the half-life for radioactive strontium-90 is 28 years. NAPB-90 used a decay rate of radioactivity for the mix of fission by-products which is generally expressed as a ten-fold reduction in intensity for every seven-fold increment of time after detonation (e.g., the radiation intensity at some location on the ground 7 hours after detonation would be one-tenth as much as it was 1 hour after detonation if all the fallout had been deposited within the first hour).

3. Statistical Overview - NAPB-90 defined the total potential risk from fallout from its ground-burst weapons to encompass the entire U.S. land area. While it is recognized that specific nuclear attack scenarios and specific weather patterns will result in little or no fallout radiation in some land areas, NAPB-90 makes no attempt to predict such an outcome.

The magnitude of this potential risk is represented with maps and statistics in Annex B.

4. Methodology Employed - Predicting the potential distribution of delayed fallout is a difficult and uncertain task. NAPB-90 employed the GUISTO-DNAF-1 fallout model to determine potential distribution patterns. This model is efficient in determining potential fallout distribution patterns for the small-yield, ground-burst weapons (high kiloton to low megaton ranges), characteristic of weapons used in NAPB-90 (see Part 2.C., "Weapon Inventory Base"). The model incorporates wind speeds and directions ("wind shears") for various altitudes up to the height reached by the weapon's mushroom cloud, integrating all data necessary to estimate unidirectional downwind fallout distributions.

To calculate potential fallout distributions "most probable" winds for each month of the year were used. The wind patterns were developed by the U.S. Air Force Environmental Technical Applications Center following analysis of the period January 1977 through September 1981. Within this period, a specific day for each month was chosen which represented the most typical surface and upper air flow patterns, together with wind patterns for the day preceding and following the date chosen. These wind patterns are those which could most probably be expected to occur any day of a month barring unseasonal weather or future atmospheric changes to current weather patterns.

In addition to calculations described above, the results of a Defense Nuclear Agency study which assessed fallout shelter protection factors was incorporated. This study used a simulated U.S. attack with ground-burst weapons corresponding closely with the pattern used in NAPB-90. The study simulated fallout distribution using 40 randomly selected wind patterns from weather data over a 5-year period.

Both of these probable fallout distributions were used to determine the highest dose reading reached within each county unit in the U.S. This reading was recorded as the degree of potential risk for that county. The probability of the county receiving this dose over a 1-week period was not considered, but it can be said to range from "greater than zero" to 100 percent. The depicted potential risk areas in Annex B should, therefore, not be interpreted as a prediction of the fallout risk resulting from any nuclear attack. The distribution of actual fallout would be driven by weather conditions extant at the time of the attack.

As pointed out earlier, predicting potential fallout distribution is a difficult and uncertain task. Within the current state-of-the-art, there are distinct possibilities of a priori errors in calculations. In addition, there is the possibility of abherent, unseasonal weather patterns on any day of the year.

NAPB-90 defines four degrees of potential fallout risk. Each definition is determined by the degree of influence specific protection measures would have on mitigating human exposures to gamma radiation. In this context, the following considerations were examined to determine the degrees of potential fallout risk:

- The mitigation of a 1-week, unprotected[1/] exposure in relation to the protection factor (PF)[2/] afforded by various shelters; and

- The kind, degree, and utility of in-place or crisis-generated shelter necessary to permit continued life support in the area; and the cost, total effort, preparation time, and efficacy of such shelter.

Specific criteria used in choosing risk level demarcations are included in discussions of these areas.

a. Very High Fallout Risk

(1) Definition - A Very High Fallout Risk Area is defined as an area which has the potential to receive a 1-week unprotected radiation dose of equal to or greater than 15,000R (nominally up to 100,000R).

(2) Criteria - If the radiation levels identified as characterizing a Very High Fallout Risk Area should actually occur, death for the resident population without very high quality protection would be almost certain. Because such high quality shelter protection factors (PF's) would be

1/ Outdoor fallout doses were calculated with no consideration for natural reductions in that dose which could be provided by the environment such as nearby buildings, lakes, ponds, streams, and surface irregularities. Average dose reductions for many outside locations might easily be half or more of the NAPB-90 levels calculated.

2/ The protection factor (PF) of a shelter is an expression of the effectiveness of the mass or shielding provided by the structure to attentuate gamma radiation (e.g., in a PF 100 shelter, the dose rate of gamma radiation would be .01 of the outside dose rate).

needed, adequate protection in the area may be difficult, if not impossible, to find.

Chart B-3a and B-3b illustrate the consequences of selecting protection levels ranging from PF 5 through PF 500. It should be pointed out that exact radiation levels can never be determined for specific points within this area in advance of fallout arrival. Hence, a minimum PF level for the entire area cannot (and should not) be defined. Shelter with the highest PF possible should always be used in planning.

Chart B-3a. PROBABLE CONDITION OF MAJORITY OF SURVIVORS IN VERY HIGH FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Medical Care Needed	Able to Work	Probable Death Rate	Comments
PF 5 PF 10 PF 20	3000R + 1500R + 750R +	Yes	No	100%	Deaths would probably occur in two weeks or less
PF 30	500R +	Yes	No**	More than 50%	Deaths would occur in about one month
PF 40 PF 60	375R + 250R +	Yes	No**	Less than 50%	Deaths would occur in 30 to 60 days
PF 80 PF 100 PF 200	188R + 150R + 75R +	No	Yes	Less than 5%	Deaths would occur in 60 or more days
PF 500	30R +	No	Yes	None	No symptoms

* Based on the lowest potential doses; at the practical upper limit of this area (approximately 100,000R dose), only shelter with a PF of 2000 or more can mitigate against probable illness and death.

** Except during illness-free latent period.

Survivors in an area of this type face the possibility of continuing to mitigate the radiation risk beyond 1-week in order to sustain life and health. Outdoor radiation levels in this area may still be high enough at the end of 1-week to severely limit outdoor activity and may require frequent and continued stay within shelter to limit additional exposures through the end of the first month. This longer in-shelter period and limited time for outdoor activity would require advance preparations to sustain life (stocking of food, water, sanitation equipment, etc.).

Chart B-3b. POTENTIAL LONG-TERM EFFECTS ON SURVIVORS IN VERY HIGH FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Additional Survivor Cancer Deaths	Additional Deaths From Genetic Damage in Future Generations
PF 5 PF 10 PF 20	3000R + 1500R + 750R +	No survivors	No progeny
PF 30	500R +	23 to 30%	2.6 to 3.5%
PF 40 PF 60	375R + 250R +	15 to 23%	1.8 to 2.6%
PF 80 PF 100 PF 200	188R + 150R + 75R +	4.5 to 11%	.53 to 1.3%
PF 500	30R +	0 to 1.4%	0 to .21%

* Based on assumption that sheltered survivors receive an additional dose over the longer term equal to that received in shelter, i.e., double the shelter dose received in 1 week.

The very high PF ratings needed in this area are generally found only in buildings of massive construction, mines, caves, tunnels, and the like. These facilities would have to be prepared in advance for occupancy.

(3) Overview - The total potential Very High Fallout Risk Areas cover approximately 421,835 square miles of the U.S., with a resident population of 9.582 millions. This constitutes 12.1 percent of the total U.S. land area, and 4.2 percent of the national population.

b. High Fallout Risk

(1) Definition - A High Fallout Risk Area is defined as an area which has the potential to receive a 1-week total radiation dose of equal to or greater than 6,000R but less than 15,000R.

(2) Criteria - If the radiation levels that characterize a High Fallout Risk Area should occur, eventual death from radiation is almost certain for resident populations unless they find shelter with relatively high protection factors (PF's).

Charts B-4a and B-4b illustrate the consequences of selecting PF levels ranging from PF 5 through PF 500. It should be pointed out that exact radiation levels can never be determined for specific points within this area in advance of fallout arrival. Hence, a minimum PF level for the entire area cannot (and should not) be defined. Shelters with the highest PF possible should always be used in planning.

Chart B-4a. PROBABLE CONDITION OF MAJORITY OF SURVIVORS IN HIGH FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Medical Care Needed	Able to Work	Probable Death Rate	Comments
PF 5 PF 10 PF 20	1200R-3000R 600R-1500R 300R-750R	Yes	No	100%	Deaths would probably occur in two weeks or less
PF 30	200R-500R	Yes	No**	More than 50%	Deaths would occur in about one month
PF 40 PF 60	150R-375R 100R-250R	Yes	No**	Less than 50%	Deaths would occur in 30 to 60 days
PF 80 PF 100 PF 200	75R-188R 60R-100R 30R-75R	No	Yes	Less than 5%	Deaths would occur in 60 or more days
PF 500	12R-30R	No	Yes	None	No symptoms

* Based on the highest potential doses; further mitigation of illustrated conditions would occur at lower dose ranges.

** Except during illness-free latent period.

Chart B-4b. POTENTIAL LONG-TERM EFFECTS ON SURVIVORS IN HIGH FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Additional Survivor Cancer Deaths	Additional Deaths From Genetic Damage in Future Generations
PF 5 PF 10 PF 20	1200R-3000R 600R-1500R 300R-750R	No survivors	No progeny
PF 30	200R-500R	23 to 30%	2.6 to 3.5%
PF 40 PF 60	150R-375R 100R-250R	15 to 23%	1.8 to 2.6%
PF 80 PF 100 PF 200	75R-188R 60R-100R 30R-75R	4.5 to 11%	.53 to 1.3%
PF 500	12R-30R	0 to 1.4%	0 to .21%

* Based on assumption that sheltered survivors receive an additional dose over the longer term equal to that received in shelter, i.e., double the shelter dose received in 1 week.

Survivors in areas of this type may face the possibility of continuing mitigation of the radiation risk beyond 1 week in order to sustain life and health. Outdoor radiation levels could be high enough at the end of 1 week to place a limit on time for outdoor activities and may require continued use of the shelter to limit additional exposures through the end of the first month. The longer in-shelter period which may be required in this area would mean advance preparations to sustain life (stocking of food, water, etc.) are a necessary measure.

(3) Overview - The total potential High Fallout Risk Areas cover approximately 614,508 square miles of the U.S., with a resident population of 48.712 millions. This constitutes 18.0 percent of the total U.S. land area, and 21.3 percent of the national population.

c. Medium Fallout Risk

(1) Definition - A Medium Fallout Risk Area is defined as an area which has the potential to receive a 1-week unprotected radiation dose of equal to or greater than 3,000R but less than 6,000R.

(2) Criteria - If the fallout levels that characterize a Medium Fallout Risk Area should actually occur, death or debilitating illness from radiation is certain for resident populations without adequate shelter. Charts B-5a and B-5b illustrate the consequences of selecting PF

Chart B-5a. PROBABLE CONDITION OF MAJORITY OF SURVIVORS IN MEDIUM FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Medical Care Needed	Able to Work	Probable Death Rate	Comments
PF 5	600R-1200R	Yes	No	100%	Deaths would occur in two weeks or less
PF 10	300R-600R	Yes	No**	More than 50%	Deaths would occur in about one month
PF 20	150R-300R	Yes	No**	Less than 50%	Deaths would occur in 30 to 60 days
PF 30 PF 40 PF 60 PF 80	100R-200R 75R-150R 50R-100R 38R- 75R	No	Yes	Less than 5%	Deaths would occur in 60 or more days
PF 100 PF 200 PF 500	30R-60R 15R-30R 6R-12R	No	Yes	None	No symptoms

* Based on the highest potential doses; further mitigation of illustrated conditions would occur at lower dose levels.

** Except during illness-free latent period.

levels ranging from PF 5 through PF 500. It should be pointed out that exact radiation levels can never be determined for specific points within this area in advance of fallout arrival. Hence, a minimum PF level for the entire cannot (and should not) be defined. Shelter with the highest PF possible should always be used in planning.

Chart B-5b. POTENTIAL LONG-TERM EFFECTS ON SURVIVORS IN MEDIUM FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Additional Survivor Cancer Deaths	Additional Deaths From Genetic Damage in Future Generations
PF 5	600R-1200R	No survivors	No progeny
PF 10	300R-600R	23 to 30%	2.6 to 3.5%
PF 20	150R-300R	15 to 23%	1.8 to 2.6%
PF 30	100R-200R		
PF 40	75R-150R	4.5 to 11%	.53 to 1.3%
PF 60	50R-100R		
PF 80	38R-75R		
PF 100	30R-60R		
PF 200	15R-30R	0 to 1.4%	0 to .21%
PF 500	6R-12R		

* Based on assumption that sheltered survivors receive an additional dose over the longer term equal to that received in shelter, i.e., double the shelter dose received in 1 week.

Survivors in this area may face the possibility of continuing to use shelters beyond 1 week in order to sustain life and health. Potential outdoor radiation levels may be moderately high enough at the end of 1 week to require careful area monitoring to limit additional exposure from outdoor activity. Continued use of shelter beyond 1 week following outdoor activity may also be required through the end of the first month and would require modest preparations to sustain life (stocking of food, water, etc.).

(3) Overview - The total potential Medium Fallout Risk Areas cover approximately 578,616 square miles of the U.S., with a resident population of 62.702 millions. This constitutes 16.9 percent of the total U.S. land area, and 27.4 percent of the national population.

d. Low Fallout Risk

(1) Definition - A Low Fallout Risk Area is defined as an area which has the potential to receive a 1-week unprotected radiation dose of less than 3,000R.

(2) Criteria - If the fallout levels that characterize a Low Fallout Risk Area should occur, debilitating illness and possible death are certain for resident populations without adequate shelter. Charts B-6a

and B-6b illustrate the consequences of selecting protection levels ranging from PF 5 through PF 500. It should be pointed out that exact radiation

Chart B-6a. PROBABLE CONDITION OF MAJORITY OF SURVIVORS IN LOW FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Medical Care Needed	Able to Work	Probable Death Rate	Comments
PF 5	600R or less	Yes	No**	More than 50%	Deaths would occur in about one month
PF 10	300R or less	Yes	No**	Less than 50%	Deaths would occur in 30 to 60 days
PF 20	150R or less	No	Yes	Less than 5%	Deaths would occur in 60 or more days
PF 30	100R or less				
PF 40	75R or less				
PF 60	50R or less	No	Yes	None	No symptoms
PF 80	38R or less				
PF 100	30R or less				
PF 200	15R or less				
PF 500	6R or less				

* Based on the highest potential doses; further mitigation of illustrated conditions would occur at lower dose levels.

** Except during illness-free latent period.

Chart B-6b. POTENTIAL LONG-TERM EFFECTS ON SURVIVORS IN LOW FALLOUT RISK AREAS*

Using Shelter Protection Factor	Potential In-Shelter One Week Dose Range	Additional Survivor Cancer Deaths	Additional Deaths From Genetic Damage in Future Generations
PF 5	600R or less	23 to 30%	2.6 to 3.5%
PF 10	300R or less	15 to 23%	1.8 to 2.6%
PF 20	150R or less	4.5 to 11%	.53 to 1.3%
PF 30	100R or less		
PF 40	75R or less		
PF 60	50R or less	0 to 1.4%	0 to .21%
PF 80	38R or less		
PF 100	30R or less		
PF 200	15R or less		
PF 500	6R or less		

* Based on assumption that sheltered survivors receive an additional dose over the longer term equal to that received in shelter, i.e., double the the shelter dose.

levels can never be determined for specific points within this area in advance of fallout arrival. Hence, a minimum PF level for the entire area cannot (and should not) be defined. Shelter with the highest PF possible should always be used in planning.

Continued use of shelter in this type of area beyond 1 week might not be necessary. As a precaution, however, unnecessary outdoor work should be avoided until all necessary radiological monitoring and decontamination has been completed.

(3) Overview - The total potential Low Fallout Risk Area covers approximately 1,803,733 square miles of the U.S., with a resident population of 107.867 millions. This constitutes 52.8 percent of the total U.S. land area, and 47.1 percent of the national population.

C. Thermal and Secondary Blast Fire Risk

1. General Overview - This risk accompanies the direct effects risk discussed in A., above. There are two principal causes of fire in direct effects risk areas: primary fires ignited directly by the thermal pulse or "heat flash" of a nuclear detonation; and secondary fires started by blast effects damage on electrical connections, gas lines, heating units, etc.

About 35 percent of the energy of an air-burst nuclear weapon is released as thermal energy or "heat flash." In weapon yields in hundreds of kilotons the duration of this period of energy radiation is very short (a flash of light) and the heat from the fireball is translated almost instantly to the surrounding area. In larger weapons (a megaton or greater) the fireball is slower in forming and is of somewhat longer duration. Therefore, in large weapons, the heat from the fireball is prolonged in areas of high overpressure but is proportionally less than the energy transmitted at low overpressure distances by the smaller-yield weapons. (Note: for determination of the fire risk, NAPB-90 assumed weapon yields characteristic of the 1985-1990 strategic inventories, i.e., weapons in the 500 kiloton to 1.5 megaton range.)

Thermal energy is measured in the number of calories per square centimeter (abbreviated "cal/cm^2") delivered to exposed areas. A calorie is the amount of heat necessary to raise the temperature of 1 gram of water 1 degree Celsius. The rate at which the calories are transmitted over time is also an important aspect of ignition. For weapons characteristic of the NAPB-90 inventories, it was assumed that thermal energy of the explosion is delivered almost "instantaneously" to exposed areas, i.e., at a very high rate.

The extent of the thermal effect of a nuclear weapon is subject to natural variations in the atmospheric conditions as well as the shielding ("shadow") provided by adjacent buildings, trees, hills, and the like. Likewise, any windows facing away from the fireball would receive little or no thermal energy. In addition to shielding, atmospheric conditions (such as rain or fog) would markedly reduce the transmission of the thermal energy and, thus,

subsequent primary fire starts. Even minor shielding can have a mitigating effect on the amount of heat transmitted beyond the shielding: ordinary window glass and screens can reduce heat transmission into a room by as much as 20 percent or more.

Secondary fires may result from the disruption of building furnaces, gas lines, electric lines, and the like, and are independent of those influences mentioned above affecting the number of primary fire starts, since secondary fires are generated by damage and destruction from blast overpressure.

All NAPB-90 discussions in this section on the risk of potential primary and secondary fires are based on the assumption of a nuclear weapon detonated at its optimum height of burst to maximize the area covered by a blast overpressure of 10.0 psi or more, and under clear weather conditions which allow a visibility of 10 miles or more.

2. Composition of the Fire Risk - Factors influencing the magnitude of the fire risk are:

- The type of blast damage within the area;
- The number of primary and secondary fires originating (and not suppressed) within the area;
- The density of construction of the fire area, usually defined as the fraction of ground covered by buildings;
- The number of buildings within the area which are burning at the same time (usually expressed as a percentage of buildings);
- The amount of immediate fuel available to the fire;
- The weather conditions at the time of burning; and,
- The season of the year.

An example of the relationship of these factors is presented below. It must be stressed that such examples are illustrative of the potential fire risk and are based upon certain assumptions of the factors influencing the magnitude of the fire risk. Emergency planning requires an assessment of the actual values of the factors which influence the fire potential of tracts within a Direct Effects Area. A comprehensive assessment can be conducted only by fire professionals who have a working knowledge of the technology of fire and who can define the "real-world" fire risk to an area. Fire risk definitions in NAPB-90 are illustrative of the potential risk and are not predictive.

a. Origination

(1) Relationship to Overpressure - There is close relationship between the level of blast overpressures from air-burst weapons and the thermal energy received at any given overpressure. For example, the rationale

designating 2.0 psi overpressure limit as the practical limit of major thermal-induced primary fires is based on the fact that for most air-burst weapons, the 2.0 psi boundary coincides with a delivered thermal energy about 12.0 cal/cm^2--approximately the level of energy at which nearly all exposed easily flammable substances would ignite. This relationship, however, does not hold true between low air-bursts and surface-bursts of the same weapon yield.

Although little research has been done at low overpressure ranges on levels of thermal energy transmission, it is almost certain that primary fire ignitions could occur within the entire area of 0.5 psi and greater overpressure.

The level of damage produced by certain blast overpressures can affect fire growth and spread. For example, damage from blast overpressures in the 2.0 to 5.0 psi range is generally characterized by damaged but standing buildings amid a debris field--conditions favoring the spread, growth, and severity of fire. On the other hand, blast overpressures above 5.0 psi tend to result in a large debris field within which fire spread and growth could be much slower, and the severity of fires could be less intense.

(2) Primary Fire Starts - For all easily flammable materials exposed ("unshielded") to the thermal flash, the possibility exists that a primary fire may start if the material:

- Receives sufficient calories per square centimeter at a sufficient rate (i.e., over a very short period of time);
- Is not extinguished by the following blast wave or by immediate fire suppression actions; and,
- Is collocated with other, "heavier" fuel to sustain the initial ignition.

Ignition of commonly found outdoor "trash"--such things as newspapers, cardboard cartons, dried leaves--will usually occur at relatively low thermal exposures (about 5 to 7 cal/cm^2). By themselves, however, these fuels rarely can generate a sustained fire. Of much greater concern are ignitions of materials most commonly found indoors where a thermal ignition of things like curtains or drapes may spread to other material within the room. The risk from primary ignitions is highest when both the "tinder" with which to begin the fire, and substantial, heavier fuel with which to provide for continued fire growth are present. While weapon testing has indicated that this type of fire rarely occurred below 2.0 psi overpressure, primary ignitions cannot be categorically ruled out for this area.

Table C-1 shows extrapolated weapons test data on the estimated primary fire starts which might be expected to occur in exposed rooms from an air-burst, 1.0 megaton weapon on a clear day. Note that primary fire starts below 2.0 psi could occur but are considered the exception.

Table C-1. Estimated Primary Fire Starts Per 1000 Exposed Rooms

Blast Overpressure	Fires in Commercial Buildings	Fires in Private Residences
0.5 psi	Possible but Rare	Possible but Rare
1.0 psi	Probably None	Probably None
2.0 psi	Approximately 1%	Less than 1%
3.0 psi	Approximately 20%	Approximately 10%
5.0 psi	Approximately 38%	Approximately 21%

Some visual evidence suggested at Hiroshima and Nagasacki that the blast wave which followed thermal radiation may have extinguished some primary ignitions (although no firm proof was found to support this assumption). However, subsequent shock tunnel tests of room fires similar to primary ignitions seemed to suggest that some proportion of primary fires will be extinguished by the blast wave and it will slow, but not stop, fire growth.

(3) Secondary Ignitions - As stated earlier, the damage and destruction of the blast wave can create secondary fires from a variety of causes. At Hiroshima, for example, a great number of fires were caused by the overturning of hot charcoal cooking braziers commonly found in Japanese homes.

Secondary fires present a potential risk regardless of local weather conditions which might inhibit primary ignitions and could also be more extensive in the case of ground-burst weapons. Advance preparations (such as shutting off electrical power and gas supplies) could significantly reduce, but probably not eliminate, secondary fires.

Studies and research suggest that statistically in the area receiving 2.0 psi to 5.0 psi overpressure up to six significant secondary fire starts might be expected for every million square feet of building floor space. In a predominantly residential area, however, the number of such starts might be half as many. Theoretically, this assessment suggests an important functional relationship between the degree of blast damage and potential secondary fire starts.

b. Growth - As noted previously, there are a number of factors which influence fire growth. These are discussed below in illustrative applications of fire growth factors of various combinations. The potential growth of individual fires into large group or mass fires, as well as "firestorms," is also discussed. In the example presented, influences of weather and the season of the year on the growth and severity of fire are not factored.

(1) Area Density - Probably one of the most important factors influencing fire growth and severity is the amount of open space between construction in a given area. This is usually expressed as the percent of land area which is under roof (streets, parks, parking lots, yards, and the like, are considered open space). Suburban single family residential areas,

for example, typically are 20 percent or less "built up," while an inner city tenement district may be built up 50 percent or more.

Table C-2 shows illustrative area coverages for some types of construction.

Table C-2. Illustrative Area Coverage

General Type of Area Construction	Illustrative Area Covered by Buildings[1/]
Tenement/Townhouse	10 to 50 percent
Industrial	20 to 40 percent
High Rise Commercial	20 to 40 percent
Public Use Buildings	20 to 40 percent
Apartments (Fire Resistant)	10 to 25 percent
Warehousing/Storage	10 to 25 percent
Industrial Park	Up to 25 percent
Single Homes (All Types)	Up to 20 percent

1/ Percent of square mile covered by roof

The less open space between burning buildings, the more likely that fires will spread to buildings not previously ignited. Spread is achieved by three means of energy transfer: convection, radiation, and firebrands.

- Convection raises the temperature of nearby combustibles by the contact of flame or hot gases and is most likely to occur when buildings are immediately adjacent or very close to each other, as in a highly built-up area.

- Radiation from a burning structure raises the temperature of nearby combustibles in a manner similar to the thermal radiation of the weapon but at a very much lower rate.

- Firebrands from a burning building when carried aloft by wind or hot air convection currents can cause ignitions in other buildings and in other combustible material (such as debris) over a wide, downwind area.

It is not known how fire spreads in large debris fields with little or no structures standing.

(2) Simultaneous Burning - Another important influence on the growth and severity of fires is the number of standing buildings burning at the same moment within the area. Usually this is expressed as the percentage of total buildings within a square mile which are burning simultaneously. The importance of this influence was demonstrated in World War II and subsequently verified by controlled fire experiments.

(3) Fuel Load - The fuel in a building is measured in pounds of combustible material per square foot of floor space. This figure would represent the combined fuel of a building and its contents. For example, the fuel load of the contents of a single family residence might average

about 3.5 pounds per square foot of floor, while the combined fuel load of both contents and building might be 10 to 20 pounds or more per square foot for each floor of the structure.

The heat of combustion of the fuel is measured in kilowatt hours per pound of fuel. Each pound of available, burned fuel can be expected to release about 2.3 kilowatt-hours of energy (although many synthetic substances have a higher potential for energy release).

Table C-3 shows illustrative ranges of fuel loading for various types of building construction.

Table C-3. Illustrative Ranges of Fuel Loading

General Type of Area Construction	Illustrative Fuel Load Per Square Foot, Per Floor*
Warehousing/Storage	20 to 80 pounds
High Rise Commercial	10 to 40 pounds
Tenement/Townhouse	10 to 30 pounds
Industrial	5 to 30 pounds
Industrial Park	10 to 30 pounds
Frame or Brick Single Homes	10 to 20 pounds
Public Use Buildings	5 to 10 pounds
Single Homes (Fire Resistant)	5 to 10 pounds
Apartments (Fire Resistant)	3 to 5 pounds

*Building and sum of contents

c. Severity - Predicting the severity of fires is an uncertain science despite extensive research on World War II mass fires which occurred in German and Japanese cities. Some of the very large mass fires called "firestorms" by a German journalist had characteristics which were new to previous fire experience. In broad qualitative terms, fire research and study of the firestorm events following attacks on Heilbronn, Hamburg, Dresden, and Darmstadt, Germany, show that a firestorm event is accompanied by:

- High-velocity, in-rushing winds at the periphery of the fire area;
- A well-developed convection or smoke column; and,
- Little spread beyond the area containing the initial, merged fires.

Research also indicated that large fires, including firestorm events, will not develop without adequate fuel within the area of initial fires, coupled with a very high rate of fuel consumption. Most importantly, the studies showed that the level of damage from high-explosive bombs used before incendiary bombs played a significant role in the formation of the firestorm. The damage environment created was conducive to the rapid burning which took place. Four basic criteria were determined to be present in the firestorm events listed above. In each of these events:

- The average fuel loading per square foot of the entire fire area was at least 8 pounds (buildings and their contents);

- At least half of the standing, damaged buildings within the area were burning simultaneously and vigorously within a short time following initial fire starts;

- Initial surface winds at the time of the attack were less than 8 miles per hour; and,

- The firestorm area was greater than 0.5 square miles.

Illustrative examples on severity given below will address all of these criteria except weather (which is assumed to be "ideal").

(1) Relationship to Overpressures - As stated earlier, there is a close relationship between blast overpressure levels and characteristics which seem to replicate the German firestorm experiences. But while mass fire experiments in the 1960's tended to confirm much of the criteria for a firestorm occurrence (particularly those dealing with fuel consumption and burn rate), it is not at all clear whether fires in a nuclear effects environment would develop in the same manner.

Weapon test data show that buildings within the 2.0 to 5.0 psi overpressure range of a nuclear weapon would generally be heavily damaged but standing. Portions of this blast area might include certain of the necessary requirements for the generation of a firestorm. On the other hand, damage in the area experiencing 5.0 psi and more overpressure would be more severe with few buildings remaining standing. This area could be expected to consist largely of rubble and debris from destroyed buildings and their contents. Here, the necessary criteria for mass fires or firestorms may not be present (which is not to say that fires could not occur).

(2) Burn Time - Fire can be said to have three burn stages--all related to time: initial ignition; vigorous burning, when a large amount of the fuel energy is expended; and residual burning, which consumes the remaining fuel. Of the three, vigorous burning is the most important in determining the severity of fires following a nuclear detonation since it usually occurs over a relatively shorter period of time than the growth and residual stages. While not totally adequate as a measure, the vigorous burn stage can be used to define a burn "rate" for comparative purposes.

Weapon tests as well as research have shown that the vigorous burn stage of a damaged but standing structure generally releases a higher proportion of the available energy than the vigorous burn stage of rubble or debris of the same fuel density.

Table C-4 shows illustrative vigorous burn rates for various types of area construction for both damaged and destroyed building modes.

Table C-4. Illustrative Vigorous Burn Rates

General Type of Area Construction	Damaged Buildings[1] Energy Released Over Time	Damaged Buildings[1] Percent of Fuel	Damaged Buildings[1] Burn Rate[3]	Rubble and Debris[2] Energy Released Over Time	Rubble and Debris[2] Percent of Fuel	Rubble and Debris[2] Burn Rate[3]
Frame or Brick Single Homes	20 min	70%	2.10	40 min	75%	1.13
Single Family (Fire Resistant)	20 min	70%	2.10	40 min	75%	1.13
Tenement/Townhouse	25 min	60%	1.44	50 min	70%	.84
Apartments (Fire Resistant)	25 min	60%	1.44	50 min	70%	.84
Warehousing/Storage	40 min	60%	.90	80 min	70%	.53
High Rise Commercial	40 min	60%	.90	80 min	70%	.53
Industrial	60 min	30%	.30	60 min	30%	.30
Industrial Park	60 min	30%	.30	60 min	30%	.30
Public Use Buildings	60 min	30%	.30	60 min	30%	.30

1/ Damage characteristic in Medium Direct Effects Risk Areas (2.0 to 5.0 psi).

2/ Damage characteristic in High and Very High Direct Effects Risk Areas (greater than 5.0 psi).

3/ Relative burn rate given by the fraction of the available energy released per hour of vigorous burn time.

(3) Potential Energy - Previous illustrations concerning area coverage of various types of construction and corresponding fuel loads gave high-low ranges for these figures. To simplify further discussion, potential energies will be determined using only the high ranges of illustrative figures previously shown. Potential energies will be calculated for both the areas identified in Table C-4., above.

The severity of mass fire is expressed in terms of the average energy output per hour of vigorous burn time measured in millions of kilowatts of energy per square mile of fire area.

Table C-5 shows illustrative energies for various types of construction. Note that to determine such potential energy, it is necessary to assume an average number of stories for buildings in each category of construction. Fire severity assessments for specific areas require estimates based on the composition of construction in these areas.

Table C-5. Illustrative kW Energy (Millions) in Construction

General Type of Area Construction	Ave Sty[1]	Area Cvrg[2]	Fuel Load[3]	Millions kW Energy Per: Sq Ft	Bldg	Sq Mile
High Rise Commercial	6	40%	40 lbs	94 kW	564 kW	6263 kW
Tenement/Townhouse	3	50%	30 lbs	141 kW	423 kW	2936 kW
Warehousing/Storage	2	25%	80 lbs	117 kW	235 kW	2610 kW
Industrial	2	40%	30 lbs	240 kW	47 kW	1566 kW
Public Use Buildings	4	40%	10 lbs	8 kW	31 kW	1044 kW
Industrial Park	2	25%	30 lbs	15 kW	29 kW	979 kW
Frame or Brick Homes	1.5	20%	20 lbs	55 kW	55 kW	392 kW
Apartments (Fire Res)	3	25%	5 lbs	12 kW	35 kW	245 kW
Single Homes (Fire Res)	1.5	20%	10 lbs	27 kW	41 kW	190 kW

1/ Assumed average height (stories) of all buildings in the area.

2/ Highest illustrative square mile area coverage by roof.

3/ Highest illustrative per square foot fuel load for building and contents.

To obtain an average rate of kilowatt energy release per hour per square mile, the burn rate for each type of construction must be considered.

Carrying over data illustrated in Table C-5, Table C-6a illustrates the potential kilowatt energy in a Medium Direct Effects Risk Area (2.0 to 5.0 psi overpressure) assuming 100 percent of the damaged, standing buildings are burning simultaneously at a vigorous burn rate, an extremely unlikely situation.

Table C-6a. Illustrative Energy Release With All Buildings Burning in Medium Direct Effects Risk Area (2.0 to 5.0 psi)

General Type of Area Construction	Millions of kW Potential Sq Mile Energy[1]	Burn Rate	Millions of kW Energy Release Per Sq Mile[2]
High Rise Commercial	6263 kW	.90	5736 kW
Tenement/Townhouse	2936 kW	1.43	4198 kW
Warehousing/Storage	2610 kW	.90	2349 kW
Frame or Brick Single Homes	392 kW	2.12	831 kW
Industrial	1566 kW	.30	470 kW
Single Homes (Fire Resistant)	196 kW	2.12	416 kW
Apartments (Fire Resistant)	245 kW	1.43	350 kW
Public Use Buildings	1044 kW	.30	313 kW
Industrial Park	979 kW	.30	294 kW

1/ All buildings; data carried from Table C-5.

2/ Potential average rate of kW energy per square mile (in millions of kW) if all buildings in the area are in vigorous burn stage.

Table C-6b illustrates the same calculations of potential energy release in kilowatts in the High and Very High Direct Effects Risk Areas (greater than 5.0 psi overpressure) if 100 percent of the rubble and debris from this construction are burning simultaneously at a vigorous burn rate, again, an extremely unlikely situation.

Both Table C-6a and C-6b will serve as a base for determining the average kilowatt energy release for more realistic assumptions of the numbers of buildings in simultaneous, vigorous burn stages which will allow an assessment of the possibility of mass fire or firestorm events.

Table C-6b. Illustrative kW Energy With Simultaneous Rubble and Debris Burning in High and Very High Direct Effects Risk Area (greater than 5.0 psi)

General Type of Area Rubble or Debris	Millions of kW Potential Sq Mile Energy[1/]	Burn Rate	Millions of kW Energy Release Per Sq Mile[2/]
High Rise Commercial	6244 kW	.53	3309 kw
Tenement/Townhouse	2940 kW	.83	2440 kW
Warehousing/Storage	2604 kW	.53	1380 kW
Industrial	1568 kW	.30	470 kW
Frame or Brick Single Homes	392 kW	1.14	447 kW
Public Use Buildings	1036 kW	.30	311 kW
Industrial Park	980 kW	.30	294 kW
Single Family (Fire Resistant)	196 kW	1.14	223 kW
Apartments (Fire Resistant)	252 kW	.83	209 kW

1/ All rubble and debris from buildings.

2/ Potential average energy release in millions of kW per square mile if all rubble and debris from buildings are in vigorous burn stage.

(4) Mass Fire/Firestorm Potential - Analyses of World War II mass fires concluded that the severity of fires can be expressed as an average kilowatt energy release per square mile of fire area. Many such fires were classified as group fires since the area covered by the conflagration was characterized by isolated city blocks burning simultaneously and vigorously but not merging. Group fires of this kind were estimated to generate energy releases of from 25 to 300 million kilowatts. Included in this category were the fires which followed the atomic bomb attacks on Hiroshima and Nagasaki. While extremely dangerous to life, the severity of fires in both of these cities was less than that generated by conventional bombing in the Tokyo fire raids carried out some weeks before the dropping of the atomic bombs.

The chief factors involved in estimating potential fire severity have been covered before and will not be repeated here. An illustration of the effect of these factors is, however, pertinent. The Hamburg firestorm event provides an example case:

- The average fuel load of the area (including all buildings and contents and considering the density of construction) was estimated to be 70 pounds per square foot of fire area. At 2.3 kilowatt-hours per pound this translated into 163 potential kilowatt-hours per square foot or about 4567 million kilowatt-hours per square mile.

- It was estimated that about 45 percent of the buildings were in a vigorous burn stage simultaneously during the firestorm; therefore, about 2055 million kilowatt-hours were released per square mile of burn area.

- The firestorm lasted about three hours and, therefore, the hourly average release was about 676 million kilowatt-hours.

From the above, an estimate of the possibility of a firestorm would be a combination of contributing factors which could lead to an average energy release of at least 650 million kilowatt-hours or more per square mile. However, potential energy releases lower than this level have also been shown to be extremely dangerous. Estimates derived from large burn tests show that extreme life-threatening situations can develop from a combination of extremely high air temperatures, smoke and combustion-generated gases, and the rapid rise in carbon monoxide when the average energy release approaches 300 million kilowatt-hours per square mile. Fatality rates also increase sharply as this level is approached.

Table C-7a illustrates the changes in per square mile energy release rates when various percentages of buildings are burning simultaneously within the Medium Direct Effects Threat Area (2.0 to 5.0 psi). Likewise, Table C-7b illustrates the changes in per square mile energy release rates when various percentages of building rubble and debris are burning simultaneously within the High and Very High Direct Effects Threat Areas (greater than 5.0 psi).

Table C-7a. Illustrative Results of Simultaneous Burning in Medium Direct Effects Risk Area (2.0 to 5.0 psi)

General Type of Area Construction	Average Square Mile Rate of Energy Release (Millions of kW) 50% Burning	40% Burning	30% Burning	20% Burning
High Rise Commercial	2819 kW*	2255 kW*	1691 kW*	1127 kW*
Tenement/Townhouse	2099 kW*	1679 kW*	1259 kW*	840 kW*
Warehousing/Storage	1175 kW*	940 kW*	705 kW*	470 kW*
Frame or Brick Single Homes	416 kW**	332 kW**	249 kW	166 kW
Industrial	235 kW	188 kW	141 kW	94 kW
Single Family (Fire Resistant)	208 kW	166 kW	125 kW	83 kW
Apartments (Fire Resistant)	175 kW	140 kW	105 kW	70 kW
Public Use Buildings	157 kW	125 kW	94 kW	63 kW
Industrial Park	147 kW	118 kW	88 kW	59 kW

* Firestorm theoretically possible at this average energy release rate given all previous illustrative assumptions on fuel, coverage, average stories, and burn rate.

** Level of energy release would make area extremely dangerous for survivors.

Table C-7b. Illustrative Results of Simultaneous Burning in High and Very High Direct Effects Risk Areas (greater than 5.0 psi)

General Type of Area Construction	Average Square Mile Rate of Energy Release (Millions of kW) 50% Burning	40% Burning	30% Burning	20% Burning
High Rise Commercial	1644 kW*	1315 kW*	986 kW*	658 kW**
Tenement/Townhouse	1233 kW*	986 kW*	740 kW*	493 kW**
Warehousing/Storage	685 kW*	548 kW**	411 kW**	274 kW
Industrial	235 kW	188 kW	141 kW	94 kW
Frame or Brick Single Homes	221 kW	176 kW	132 kW	88 kW
Public Use Buildings	157 kW	125 kW	94 kW	63 kW
Industrial Park	147 kW	118 kW	88 kW	59 kW
Single Homes (Fire Resistant)	113 kW	90 kW	68 kW	45 kW
Apartments (Fire Resistant)	103 kW	82 kW	62 kW	41 kW

* A firestorm is theoretically possible at this energy release rate given all previous illustrative assumptions on fuel, coverage, average stories, and burn rate.

** The level of energy release would make this area extremely dangerous for survivors.

3. Statistical Overview of Risk - NAPB-90 defines the potential risk from fire following a nuclear explosion as the total area covered by blast overpressure, i.e., any area which has the potential to experience 0.5 pounds per square inch (psi) or more. This represents 727,112 square miles of U.S. territory with an estimated resident population of 175.11 millions.

The magnitude of this risk is represented in Annex A.

4. Methodology Employed - NAPB-90 defines three levels of potential risk from fire. Each definition is driven by the likely effects of the potential fire on the life and health of the resident population. In this context, the following considerations were used in determining the degrees of fire risk:

- The potential long-term severity of the threat to survivors within a blast-damaged area through entrapment in damaged or destroyed buildings by fires of whatever origin and of whatever severity; and,

- The kind, degree, and practicality of fire suppression actions.

It should be evident from prior discussions that there must be many factors present before mass fire or firestorm can result. If, in the entire area, such factors are not found to be present following a detailed fire assessment, the defined risks will be less severe than presented below.

The defined NAPB-90 fire risks, therefore, do not predict the severity or extent of the threat itself but do point out the potential for the risk to

occur if necessary factors in the entire area (or in portions of the area) support such a conclusion.

a. Very High Fire Risk

(1) Definition - A Very High Fire Risk Area is defined as the area corresponding to the High and Very High Direct Effects Risk Areas, i.e., the area which has the potential to experience blast overpressures from a nuclear detonation equal to or greater than 5.0 psi.

(2) Criteria - In a Very High Fire Risk Area survivors would probably face life-threatening fires generated by the thermal pulse of a weapon as well as damage-caused ignitions from ruptured gas and electric lines. In this area, it will be virtually impossible to initiate fire-fighting procedures because of rubble and debris, severed waterlines, damaged or destroyed firefighting equipment, and the like. For this reason--more than for the potential severity of fires--any survivors of blast effects face death unless evacuated from this area.

In short, residents in potential Very High Fire Risk Areas face extremely dangerous blast overpressures as well as the possibility of death from ensuing fires of whatever origin or severity.

(3) Overview - The total potential Very High Fire Risk Areas in the U.S. cover approximately 96,248 square miles, with a resident population of 79.44 millions. Of the total U.S. area and population defined by NAPB-90 as under fire risk, 2.7 percent of the land area and 45.4 percent of the population fall under this risk definition. As a population group, those in Very High Fire Risk Areas represent 42.9 percent of the total population of the U.S.

b. High Fire Risk

(1) Definition - A High Fire Risk Area is defined as the area corresponding to the Medium Direct Effects Risk Area, i.e., the area which has the potential to experience blast overpressures from a nuclear detonation equal to or greater than 2.0 psi but less than 5.0 psi.

(2) Criteria - A High Fire Risk Area has the potential to experience large fires following weapon detonation which could prove fatal to survivors unless they were evacuated. The potential for such fires to originate and develop depends on the number of structures and construction type within the area and their propensity to fire growth and spread. Should a detailed fire analysis of this area reveal such characteristics, large group fires and even firestorms are possible, posing the possibility of sure death for survivors unable to evacuate the area.

Initial and subsequent firefighting procedures for large fires in this area will be difficult, if not impossible, due to limited mobility imposed by rubble and debris, the potential lack of water, and damaged or destroyed

fire-fighting equipment. Self-help fire fighting of initial ignitions (from whatever cause) may be possible but extremely difficult.

(3) Overview - The total potential High Fire Risk Areas in the U.S. cover approximately 151,535 square miles, with a resident population of 50.3 million. Of the total U.S. area and population defined by NAPB-90 as under fire risk, 4.3 percent of the land area and 28.7 percent of the population fall under this risk definition. As a population group, those in High Fire Risk Areas represent 20.8 percent of the total population of the U.S.

c. Medium Fire Risk

(1) Definition - A Medium Fire Risk Area is defined as the area corresponding to the Low Direct Effects Risk Area, i.e., the area which has the potential to experience blast overpressures from a nuclear detonation equal to or greater than 0.5 psi but less that 2.0 psi.

(2) Criteria - The most probable cause of fire in a Medium Fire Risk Area will be from indoor primary ignitions caused by the thermal radiation of the weapon. These indoor ignitions, if unchecked, have the potential to grow into larger, more threatening fires. Secondary fires in this area are possible, but not very likely. Since protective measures in this area can be effective against blast overpressures, firefighting in this area is possible (if extensive preattack preparations and training have been accomplished), but shortages or lack of water for such purposes may prove a serious problem.

Fires in this area, even though individually intense, will probably not merge into a mass fire or firestorm.

(3) Overview - The total potential Medium Fire Risk Areas in the U.S. cover approximately 479,329 square miles, with a resident population of 45.37 millions. Of the total U.S. area and population defined by NAPB-90 as under fire risk, 13.5 percent of the land area and 25.9 percent of the population fall under this risk definition. As a population group, those in Medium Fire Risk Areas represent 18.8 percent of the total population of the U.S.